February 24, 1927

Engineering News-Record

Devoted to Civil Engineering and Contracting.

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RAILROAD NUMBER

Unification of Railway Passenger Terminals

Fighting Snow on a Mountain Railway in Norway

Relocation Reduces Grades from Six to Three Per Cent

Building Concrete Roadbed for the Pere Marquette

Also

A group of short railway articles, and data on railway appliances

Heavy Grading on the Natron Cutoff in Oregon: Maximum Grade of 1.8 Per cent

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ENGINEERING NEWS-RECORD

DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

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FRANK C. WIGHT
Editor

Volume 98 NEW YORK, FEBRUARY 24, 1927 Number 8

Railway Engineering

MOST of this issue is devoted to the interests of engineers in railroad service, chiefly because attention will be centered upon their work at the approaching convention of the American Railway Engineering Association in Chicago. Few engineers are less inclined to talk or write about their work than are railway engineers, and therefore much that they do, other than spectacular construction jobs, goes unrecorded. As a result, most people consider that the construction of new railway lines is the chief work of the railway engineer. But for every such job there are many others of diverse nature. There are freight and passenger terminals to be redesigned, tracks to be maintained under dense traffic while changes in the supporting structures are made, snow to be controlled and high water to be kept within bounds so that trains may not be delayed, bridges to rebuild, grades to be improved, track to be strengthened for heavier traffic, and always the rails and ties to be kept in sound condition. A few such operations are described in this issue. It is with such problems that the large majority of railway engineers must struggle.

Atlanta Water Rate Contest

AN extreme case of the common practice of saddling the expenses of other city departments on the water-works is afforded by the recent 50 per cent increase in the water rates of Atlanta, Ga., to meet an $852,000 deficit in the school fund. Happily a water consumer—a woman—of sufficient courage and acumen has risen to the occasion and challenged both the constitutionality and the legality of the increase: the first, as being confiscatory and discriminatory; the second on the ground that the council has no authority to make water consumers pay school expenses. Faced with a temporary injunction against collecting the rates, and perhaps by an outburst of public opinion, the council now proposes a charter amendment to provide a way of meeting the school deficit that will put the burden where it belongs, on the taxpayers instead of the water consumers. It is to be hoped that the suit will come to trial and be carried to the highest court of Georgia. The high rate of increase will make the arguments against such loading of tax burdens on water consumers stand out boldly, even though the basic principles involved are the same whenever the shifting is material and clearly designed.

Overloaded Trucks

TWICE within the past week trucks loaded with cement have been noticed en route to a concrete building in New York City. They were ordinary motor trucks, four wheeled and with single solid tires. On each the cement was tiered in bags, so that a ready and fairly accurate estimate could be made of the number of sacks, and hence of the load. One of these trucks was carrying 15 tons of cement and the other 17 tons. The trucks themselves would probably weigh close to 3 tons, if not more. Twenty tons on four wheels on city streets! It is tribute to motor truck builders that a vehicle can be produced capable of carrying such a load safely and economically, but what about the streets that have to bear such an imposition of load? Is it any wonder that street paving gives way or that manholes break? The progress of such a truck through the city must be a succession of failure, failure that the citizens eventually pay for, and which can be laid only to the desire of the truckman or his client, to save a few dollars hauling cost. The city's engineers have been trying for years to have a maximum load law passed, but so far without success. Just now they are considering a proposal which would limit loading to 800 lb. per inch of tire width. Many trucks are now far beyond this limit. In the interest of public economy they should be denied the use of the streets.

Reaching the Subordinate

TO gather together in one meeting around fifteen hundred men all interested in highway engineering is an achievement, but it carries with it certain responsibilities. The Association of Highway Officials of the North Atlantic States should have all credit for the energy and co-operation that brought about the huge meeting at Atlantic City last week, but it has still a large task ahead to capitalize fully the expenditure of time and money that such a congregation of state and county employees entails. This year's convention was an improvement over the one last year in Syracuse in that many of the papers were on problems peculiar to the section of the country represented by the association. Discussion of the general highway problems that are common to all literature and conventions were in the minority, which showed a proper appreciation of the function of the regional association, but there was still too much of the overhead problem of the design, layout and policy type; problems that concern only the limited few who direct highway departments and their major subdivisions and on which the rank and file can have little influence. It is a good thing to subject this rank and file to a degree of this atmosphere, for they are the raw material out of which the future heads must be made and their thinking should be directed along such lines. But the great majority of the men at Atlantic City were from the design tables, the inspection forces and the minor supervisory positions. There should be provided for them something in the nature of the familiar road school, a place for the exchange of working ideas that they can put into use in their immediate future work. The association is young. The Atlantic City convention was only its third, and it has few precedents on which to act. It cannot fail to recognize the nature of its personnel and to arrange its future development to meet best that personnel's needs.

Economic Aspects of the Railway Tie

STEEL rails and wood ties constitute the main items of railway track, but with the great demand for ties in construction and renewal, combined with the rapid depletion of forest resources by use, waste and fire, a serious situation began to develop some years ago, threatening a shortage in the future supply of ties. While within recent years the use of treated ties has increased to such an extent as to postpone this shortage to an indefinite period, the questions of supply, quality, life and cost of ties continue to be of large importance in relation to track construction and maintenance.

This wide adoption of preservative treatment has a double economy, since it not only increases the life of durable timbers ordinarily used, but also increases the supply by permitting the use of many timbers that would be useless without such treatment. Until comparatively recently, the untreated white-oak tie was regarded as the highest grade, and the yardstick by which the value of other timbers would be measured. Treatment of white-oak was considered an unnecessary refinement, but experience has shown that it is desirable and economical. Furthermore, much of the best white-oak has been cut or is not now available for ties, so that in general the white-oak tie of today is probably inferior to the timber which was formerly rated as standard.

Tie-plate protection for wood ties is another economic feature of modern track. White-oak combines the properties of hardness and durability. But many of the timbers made available by treatment are relatively soft and would be rendered useless by wear under the rails long before it had reached its limit of durability. This condition has been met by placing metal tie-plates under the rails to distribute the load over a much greater area than that covered by the rail base. As with preservative treatment, the application of this means of protection has been found economical even for hard woods in tracks carrying heavy traffic, on account of the enormous concentrated wheel loads of modern engines and cars. There is still desirable a wide use of some rail fastening having a more secure hold than the spike commonly used, the continual slackening and driving of which is detrimental to the tie.

What of the future? Will the demand for ties decrease as the result of preservative treatment and other measures? Is there adequate supply of tie timber? Will diminishing supply and consequent increasing cost lead to the use of imported timbers? Or will the situation necessitate an increase in the use of other materials than wood? Imported ties and substitute ties now represent but an infinitesimal proportion of track mileage.

As to the supply of tie timber, there appears to be little cause for apprehension, in view of the longer life and greater variety of species made available by treatment and protection. These economic measures are further supplemented by greater care in the cutting, use and handling of ties, and by systematic inspection of ties in the track to insure that they give their full available life. On some roads, the annual renewals per mile have been reduced 50 to 60 per cent in 15 or 20 years. Under all these favorable conditions a first-class treated tie, especially of soft wood, may last nearly as long as it takes a tree to grow to tie-producing size. Again, many ties are now obtained from sections which formerly did not produce them. An urgent necessity, however, is the protection and conservation of forest timber resources.

Although railway extension has been slack for some years it is again on the upward trend, and the slackness has been counterbalanced in part by great activity in double-tracking, with consequent large demand for ties. Some dealers predict that the demand for first-class ties will exceed the supply, but this seems improbable in face of the conditions already reviewed. Another prediction, which makes allowance for untreated ties now in track, is that during the next few years, say 1928 to 1940, the number of ties needed annually will be about 75 per cent of that during the decade 1906-1916.

Great advance has been made in the estimating of tie life and renewals. From diagrams and tables based on the records of thousands of ties over a long term of years it is possible to forecast very closely the number of ties required for annual renewals. It is estimated that 30 per cent of the ties now in use on main tracks and 50 per cent of the ties purchased annually are treated. It remains for the railway engineers and purchasing departments, and the tie producing and wood-preserving industries, all represented by influential associations, to co-operate in raising these percentages.

Uniform specifications will aid materially in economic use of the tie-timber supply. On this basis, the American Railway Engineering Association has drafted and adopted tie specifications which have been accepted by a dozen other associations and made standard by the American Engineering Standards Committee. Some objections to these specifications are noted in an article in another column, but these objections do not appear to be supported by the tie industry. On the contrary, first-hand information indicates a general approval of the specifications.

A real need is a wider and stronger use of the adopted specifications, for failure to apply them universally is a weak point on the part of the railways. Some roads continue to use individual specifications and others use the A.R.E.A. specifications with modifications which weaken them. Particularly objectionable is slackness in grading and inspection, the result of which is that ties are accepted and paid for at higher grades than a strict interpretation of the specifications would permit. It will be remembered that a few years ago Mr. Aishton, as president of the American Railway Association, took the engineers to task rather seriously for their slowness to use in their individual practice the standards and specifications which they have approved collectively. In this way they deprive their railroads of certain definite advantages and economies.

Disposal of the small or under-size ties is a problem sometimes, but in the interests of timber conservation an attempt is being made to discourage their production. However, ties below grade may be accepted for side tracks, while ties which are small or are rejected for minor defects are sold extensively to commercial or industrial users and to short-line railroads. Mines and industries frequently purchase the cheapest ties available, with little regard for quality, but it is worth noting that some high-class industries demand ties that meet the A.R.E.A. specifications. Mine ties are often 5x7-in., 6 ft. long. Street railways generally require 6x8-in., 8 ft. long, but often accept ties inferior to the A.R.E.A. grades.

As to substitute ties. Such ties, of other materials than wood, are not a practical or economic issue at this time. Steel ties appear to be diminishing, since new ones rarely replace those removed for various reasons, while present market conditions do not favor their introduction. The concrete tie is in much the same condition, although both materials have shown good results in isolated cases. Concrete roadbed, eliminating ties, is a negligible factor as affecting tie consumption. These remarks apply to ordinary railway track. For mines, industrial railways, portable tracks and street railways there is a considerable use of steel and concrete in various forms.

In conclusion, it may be said that preservative treatment, protective appliances, systematic study and careful use of wood ties have removed any threatened shortage to an indefinite period. The next step is a stiffening in the application of the standard specifications for wood ties. Nevertheless, the American Railway Engineering Association is right in recommending continuous study of and experiment with substitute ties in preparation for possible future conditions.

Contractors as Exhibitors

WHY do contractors never exhibit? Industrial exhibitions are held some time every year in almost every city of size and almost no trade association or technical society meets in convention without an attendant exhibition. Some of these like the Chicago road show are veritable expositions of the science and art of the industrial or trade activity to which they appeal by a showing of wares. Yet almost never in the multitude of devices and services shown is the contractor or constructor represented.

The men who build the country's railways and roads and subways, its bridges and power plants, its factories and skyscrapers, its water supply and sewerage systems, and its waterways and harbors, take part in industrial exhibitions only as visitors and potential purchasers. They make no effort to show that they have anything to sell. It may be asserted that what they have to sell is the kind of thing that cannot be set up in an exhibition booth for inspection. If by any chance this is the notion which is keeping constructors from exhibiting, the sooner they disabuse their minds from it the better it will be for their minds, if not for their business.

Conviction in this opinion is intensified by a report to us of the "Progress Exposition" recently held at New Haven, Conn. There is no space nor is this the place for details, but the count showed a quarter of a million visitors and 220 separate exhibits at this New England city exhibition. One of the exhibitors was a general contractor for roads and bridges and heavy engineering works generally. We will be frank and give the name, C. W. Blakeslee & Sons, New Haven, Conn. This contractor showed cross-section drawings of New Haven harbor where the new Tomlinson bridge crosses it and others of the left pier of this bridge and paintings of quarry and underground transmission line work. There was a 6-ft.-square model of a cofferdam with rangers and braces and tie rods and on its top operated a model derrick and a model piledriver. And alongside was one of the firm's divers in suit and helmet with all his paraphernalia and with an attendant to tell how he worked and what he did. Other attendants explained the drawings and the models. And finally, says our reporter, "the exhibit had around it all the time a group of 50 to 100 people."

There is no need of saying more. Obviously, the display was practicable and could be made in any exhibition hall and evidently it interested its share of exhibition visitors. It was no more than any contractor can plan who has the enterprise to apply modern sales methods to his business.

More Technical Discussion

EVERY technical society is faced with the problem of stimulating the discussion of matters presented for consideration at its sessions. In this the American Railway Engineering Association is no exception, but because its methods of procedure are different from that of most other societies, the lack of discussion is much more serious. In the A.R.E.A. the whole time of technical sessions is devoted to the development of the best practice in the several branches of its field through standing committees whose reports lead ultimately to the modification of the association's manual. Frequently, important matter is accepted for publication in the manual without one word of discussion from the floor. More discouraging still, preliminary reports presented by committees looking toward revision of the manual will not be objected to when thus presented, and the committee, assuming that the association approves of the matter, presents it the following year in form for the manual, only to have it thrown out, occasionally upon some trivial error, and thus have it put over for a whole year.

Such procedure has been detrimental not only to the material put into the manual, but to the whole make-up of the manual. With the prospect of the publication of a new manual, the whole subject of association procedure is in need of thoughtful consideration. To stimulate such consideration, the Committee on Records and Accounts has put aside its regular assignment and asks that the association at its coming convention devote the time allotted to it to considering the possibility of evolving an entirely new manual and of changing the association's convention procedure to provide for adequate discussion. For the manual, the committee suggests employing a staff of full-time experts to undertake the revision or entire rewriting. As a stimulant of discussion at technical sessions, the committee recommends the holding of sectional meetings from which the net results will be brought to the annual meeting, as opposed to the technical division method followed by the American Society of Civil Engineers.

Whether the association adopts the recommendations of this committee or some of the others suggested by President Fairbairn during his term of office, such as organizing an official opposition, emphasizing minority committee reports, or appointing floor leaders to draw attention to controversial points, other societies will watch the outcome of its decision with a view to changing their own practice. Something ought to be done in every technical society toward promoting technical discussion and toward relieving the tedium of the presented paper or report. If the A.R.E.A. can work out a practical plan it will deserve the thanks of all engineers who attend conventions or belong to technical societies—and that includes most of the profession.

Unification of Railway Passenger Terminals

Comparative Merits of One Station and Several Stations—Different Cities as Examples—Local Conditions a Governing Factor—Railway and Municipal Co-operation

By E. E. R. Tratman
Western Editor, *Engineering News-Record*

A COMBINED railway and municipal problem which is present or impending in a number of cities is that of new or improved passenger terminals, and a proposition which may develop in many such cases is the unification of these terminals. In other words, it is the problem of the concentration of all traffic in one station instead of having it divided between two or more stations serving individual railways or groups of railways. Where a new city is planned in open country, as was the case with the still unfinished governmental capital cities of Delhi, in India, and Canberra, in Australia, it is easy to lay out railway lines and a union station in harmony with the city plan. Such design of a unit terminal, unhampered by existing conditions or occupancy, is a rather fascinating subject, but opportunities of this kind are extremely rare.

As a rule, the problem involves established terminals and various limiting conditions, and its solution means the altering or rebuilding of some existing lines in order to bring them all to one common focus at a single union or unit station. This station may occupy one of the existing sites or an entirely new site. Railway property thus set free may be developed for other railway purposes or it may be sold or transferred for municipal or private use. To effect unit operation economically under these circumstances can be no easy task. That it has been accomplished in some cases is not a strong argument in proposed cases, since every project presents its own problems.

What is Unification—As related to passenger traffic the term "unification" implies the accommodation of all the railways of a city within one union station under a single management. In this respect it differs from the unification of freight terminals, since no one station could handle the combined freight business of all the railways. The unification of freight terminals, therefore, implies the operation of all freight facilities as a multiple-unit system under one management, as discussed in *Engineering News-Record* of March 4, 1926, p. 354. The confusing of this distinction between the unification of passenger terminals and of freight terminals has led sometimes to the suggestion of impracticable plans or conditions.

Since the railway system centering at any city is formed usually by the independent growth of different lines, it is not easy to combine and connect the various main lines into a unified system with one central point or station. The difficulties will increase with the number of roads involved. They will be aggravated also where the topography is hilly or irregular and the railway lines are at different elevations.

The phrase "terminal" does not mean necessarily a dead-end railway terminus. It includes all large passenger stations through which trains may pass but which are terminal points for certain trains or divisions. Thus, the present discussion applies to the through stations at Indianapolis and Kansas City, as well as to the stub or dead-end stations at Chicago or New York. In fact, many stations comprise both stub and through features, as the Union Station at St. Paul and the Pennsylvania R.R. Station at Pittsburgh.

Analyzing the Problem—Under the various interlocking and conflicting conditions involved, the fundamental question in any individual problem of unification is: "What will be its cost and its practical and economic advantages?" To this question no general answer can be given. Each case is a problem in itself, with its own limitations and its own factors as to location, traffic and civic conditions. While no one case is a criterion for another, any one case presents lessons in what to do and what to avoid.

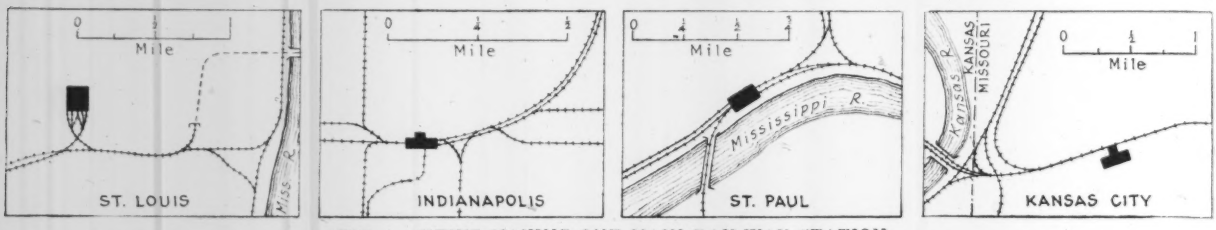


FIG. 1—CITIES HAVING ONE MAIN RAILWAY STATION

Solution of any individual problem involves many aspects, both practical and economic, and from both the railway and the municipal points of view. Among these innumerable factors are: (1) Adequacy of present stations; (2) advantages and disadvantages of proposed union station site; (3) present and prospective railway and city traffic conditions; (4) practicability of rerouting traffic or building new connecting lines; (5) cost of station, approaches and auxiliary works; (6) convenience of the traveling public; (7) character of railway traffic, or the proportions of through and local passengers; (8) relations of the several railways as competitive or connecting roads; (9) the progressive or backward attitude of the city in matters of municipal affairs and improvements.

One of the minor factors in a comparison of unit and independent stations is that of the relation of interstation traffic to the ordinary street traffic. A recent survey at Chicago showed that with nearly 30,000 persons arriving daily by 23 railroads at six terminals, about 4,000 are transferred from one station to another

by a concern operating 106 motor buses for this service. No record is given of the number employing taxicabs for such transfer.

Station Examples and Comparisons

Chicago and St. Louis—As an example of the multi-station situation consider Chicago, with six terminals for its 23 railroads, exclusive of belt and local lines. Two of these stations are modern, while authority has been given for replacing a third on a grand scale. Several rival projects provide for eliminating the other three entirely or replacing them by one new station to serve some or all of the several lines concerned. With this situation, the establishment of a single union station appears to be economically and practically impossible. Equally impossible would seem to be the conversion of the complicated network of railways in and around the city into a unified system. Not that such union station schemes have never been proposed. As a matter of fact several such propositions are on record. One curious plan provided what might be called a multiple-unit terminal, composed of a series of adjacent stations placed end to end and having a series of loop tracks. Although Chicago is on level ground, any unification project would face the problem of lines at different levels, since two of the stations have their tracks elevated, two have them depressed and two have them at street level.

As an example of the single or unit station situation, consider St. Louis, with 20 main line railroads all served conveniently in one union station. But this station was built some 35 years ago, when the railway situation and the station environment were much simpler than they are now. As a result of broad vision in the first place and of improvements from time to time, the St. Louis station is still adequate for the service required. Whether effective co-operation of the Chicago railroads could have been secured in the same way 20 or 30 years ago, and whether a common station adequate for a long period of years could have been built at that time are questions of speculative interest only.

Unit and Independent Stations

Conspicuous examples of large cities in which a single union station accommodates all the railroads are St. Louis, St. Paul, Kansas City, Indianapolis and Dallas, Texas. Examples of large cities having two or more main stations are Chicago, Boston, New York, Philadelphia, Buffalo, Detroit and Memphis. Particulars of the station conditions in a number of cities are given in the accompanying tables. Both Omaha and Seattle have two stations side by side, and different plans for the combination of all traffic in one station have been made, but have failed to meet approval of the railways.

At Cleveland, definite plans were made some years ago for a unit station on the lake front, forming one of a group of public buildings at a civic center. The other buildings were erected, but the station project was upset by a rival project for a station in the business section of the city. The latter is now being built, but will not be used by all the railways, so that there will be at least two main stations. It seems unfortunate that the original plan could not have been carried out, as the location was convenient to but not in the business district, and the building would have been a distinctive feature of the civic center.

Situations analogous to these at Omaha and Seattle are presented by Lincoln, Neb., and Springfield, Ill. At Lincoln, five trunk lines using three old stations could not agree upon plans for a revision of lines and a union station. As a result, one road is erecting for its own use a new station on the old site, and the railway situation remains unchanged. At Springfield, three railways pass through the city at street level and have their own stations. For some time the city has been trying to have these conditions improved, but the railways have not agreed to any of the plans suggested. With this station project is involved that of grade separation, which must be effected eventually.

That union stations are practicable at small as well as large cities is illustrated by Vincennes, Ind., which has one station serving all the four railways.

Broadly speaking, railroads are not favorably disposed towards union station projects. Apart from physical, operating, financial and co-operative difficulties among themselves, one strong reason for this attitude is a tendency of municipal authorities to overload such a project with street and other local improvements and to impose an excessive amount of work and expense upon the railroads. These improvements are of benefit mainly to the citizens and its street transportation, while they do not bring revenue to the railroads. Active co-operation between the railways and the city is essential to a successful general plan, but

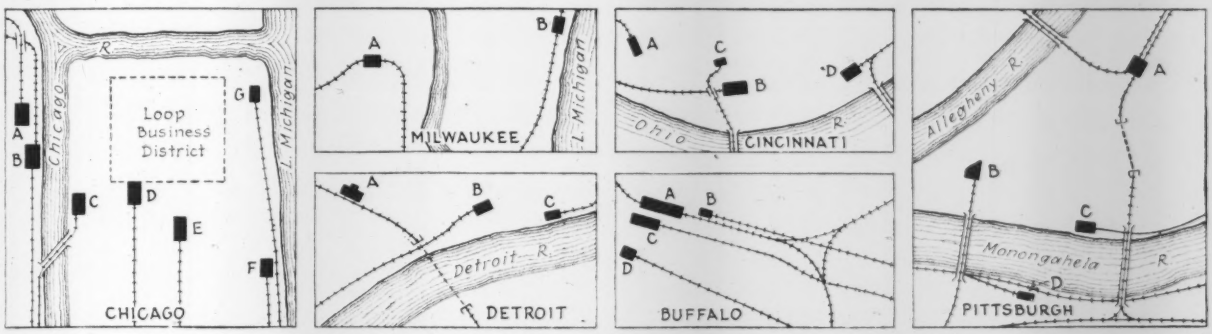


FIG. 2—CITIES HAVING SEVERAL MAIN RAILWAY STATIONS
(Not drawn to scale)

Chicago: A, Chicago & Northwestern Ry.; B, Union Station; C, Grand Central Station; D, La Salle Station; E, Dearborn Station; F, Illinois Central R.R.; G, Illinois Central suburban terminal.

Milwaukee: A, Union Station; B, Chicago & Northwestern R.R.

Detroit: A, Michigan Central R.R.; B, Fort St. Union Station; C, Grand Trunk Western Ry.

Cincinnati: A, Baltimore & Ohio R.R.; B, Central Union Station; C, Chesapeake & Ohio R.R.; D, Pennsylvania R.R. and Louisville & Nashville R.R.

Buffalo: A, Union Station; B, Erie R.R.; C, Lehigh Valley R.R.; D, Delaware, Lackawanna & Western R.R.

Pittsburgh: A, Pennsylvania R.R.; B, Pittsburgh & West Virginia R.R.; C, Baltimore & Ohio R.R.; D, Pittsburgh & Lake Erie R.R.

TABLE I—TYPICAL CITIES HAVING ONE RAILWAY STATION

Cities	Number of Railroads	Population
Augusta, Ga	6	55,700
Dallas, Texas	8	200,000
Galveston, Texas	5	49,100
Indianapolis, Ind	6	367,000
Jacksonville, Fla	5	96,500
Kansas City, Mo	13	375,000
Portland, Ore	5	260,000
St. Louis, Mo	20	830,000
St. Paul, Minn	9	248,000
Texarkana, Ark	4	10,050
Vincennes, Ind	4	18,000
Washington, D. C.	5	528,000

too often a political element is introduced and the project ceases to be regarded on its merits as a business proposition. This is probably one reason why the railways sometimes object to features which on their face appear reasonable requirements.

Railway Traffic Conditions

It might appear that if St. Louis can accommodate 20 railroads in one station, Chicago might do the same for its 23 railroads. There is an essential difference, however, in the traffic conditions of the two cities. At Chicago the railways have an enormous suburban traffic, while at St. Louis this traffic is small. Thus, three of the Chicago stations aggregate about 450 suburban trains daily, while the St. Louis station has but 30 such trains. The same three Chicago stations have also an aggregate of 270 main-line trains daily, as against 222 at St. Louis.

It has been claimed that no such heavy suburban traffic as that of Chicago could be operated satisfactorily at one station, in addition to the main line trains. But at New York, the Pennsylvania R.R. station is credited with 394 suburban trains and 164 main-line trains daily, while the Grand Central station has 240 and 190 respectively. Here again there are vital differences in local conditions. These two stations serve three railroads

TABLE II—SOME CITIES WITH MORE THAN ONE RAILWAY STATION

Cities	Number of Railroads	Number of Stations	Railroads per Station	Population
Atlanta, Ga	8	2	3 and 5	203,500
Boston, Mass	3	2	1 and 2	787,000
Buffalo, N. Y	11	4	1 to 5	544,000
Chicago, Ill	23	6	1 to 7	3,048,000
Cincinnati, Ohio	10	4	1 to 6	411,000
Cleveland, Ohio	7	5	1 to 3	960,000
Columbus, Ohio	6	2	1 and 5	285,000
Denver, Colo	7	2	1 and 6	285,000
Des Moines, Iowa	8	4	1 to 4	146,000
Detroit, Mich	8	4	1 to 3	1,290,000
Houston, Tex	7	3	1 to 5	138,000
Los Angeles, Calif	4	2	1 and 3	576,000
Louisville, Ky	9	2	5 and 4	311,000
Memphis, Tenn	8	2	3 and 5	177,000
Milwaukee, Wis	3	2	1 and 2	517,000
Minneapolis, Minn	9	2	3 and 6	434,000
Mobile, Ala	4	3	1 to 2	66,800
New Orleans, La	11	6	1 to 4	419,000
Norfolk, Va	8	5	1 to 3	174,000
Oklahoma City, Okla	6	3	1 to 3	100,000
Omaha, Neb	9	2	1 and 8	215,400
Philadelphia, Pa	3	3	1	2,008,000
Pittsburgh, Pa	5	4	1 and 2	637,000
Savannah, Ga	5	3	1 to 3	95,000
Seattle, Wash	5	3	1 to 2	320,000
Tacoma, Wash	4	2	1 and 3	106,000
Terre Haute, Ind	5	2	2 and 3	72,000
Toledo, Ohio	12	4	1 to 9	294,000

only, and have not the ramified approach lines under divided ownership which complicate the situation at St. Louis and especially at Chicago.

At the lower end of the traffic scale are the Central Union station at Cincinnati, with 147 main-line and 12 suburban trains; and one of the four Buffalo stations with 31 and 14 respectively. At Kansas City, the one station has 216 main line trains, but no suburban trains. One of the Chicago main-line terminals is peculiar in that it handles no suburban trains, for although the railroad has a very heavy suburban business it handles this at a separate terminal. Another feature in traffic conditions is where two or more stations in a city have only light traffic. In such cases, it may be well for the railways to consider the possible economics and advantages resulting from a single union station, with its facilities and staff, in place of scattered stations which are empty and idle for a large part of the time.

Unit Station Management

A union station is managed, as a rule, by a company or organization representing some or all of the railroads using it, any railroads not included in the joint ownership being accommodated as tenants. Less frequently the station is owned and operated by one of the railroads, with all the others as tenants. Of 37 union passenger stations listed in the reports of the yards and terminals committee of the American Railway Engineering Association, 24 have joint ownership. These 24 stations serve two to seven railroads each, while one of those owned by a single railroad has seven tenant railroads.

Two features in which unit or union stations differ materially and which affect the control of station traffic are: (1) Arrangement of the approach lines, and (2) equipment service rendered to the railways. As to the first, and referring to the plans in Fig. 1, compare the Kansas City station with its easy direct approach lines, and the numerous junctions and connections close to the stations at Indianapolis and St. Paul. As to service conditions, some union station organizations do nothing in the way of switching or making up trains, storing and cleaning passenger cars, or caring for locomotives of the several railways, although if the station has its own switching engines it will take care of these. At other similar stations these functions are provided for the railroads to a greater or less extent, sometimes on a comprehensive scale.

Conclusion—While the unit station plan in principle presents certain advantages to the railroads, the city and the traveling public, there are so many difficulties and objections and limiting conditions as to preclude any recommendation of general applicability. Each case is distinctly a problem in itself, and its solution depends largely upon personal attitudes and the existence or absence of co-operation, probably quite as much as upon the physical aspects of the problem. This active co-operation, to be effective, must include not only the railways among themselves, but the railways in conjunction with municipal authorities, commercial and civic associations, and local public opinion. It is evident from what has been said that the single unit station can be and has been applied to large and small cities. The main part, then, in considering any individual project, lies in an analysis of the practical and economic aspects of that particular case.

Defects in Force-Account System in India

To the article under this subject in *Engineering News-Record* February 19, p. 233, there can be added, as the investigating committee has now made its report, the statement that the excessive cost and time of construction are attributed to unsatisfactory estimates, defective organization, failure of the dredging operations and decline in value of the reclaimed land. Reduction in the area to be filled and completion on the revised plan within four years are recommended.

Railroad Tie Specification and Tie Treatment

New Classification of Ties by Size and Area Is Proposed—Needless to Group Ties by Species for Treatment

By W. F. Goltra
W. F. Goltra Tie Co., Cleveland, Ohio

ALTHOUGH uniform specifications for railway ties as adopted by the American Railway Engineering Association and the National Association of Railroad Tie Producers have now been adopted as standard by the American Engineering Standards Committee, it is my opinion that these specifications have not benefited the railways or the tie producers to any appreciable extent. On the contrary, they tend to cause more confusion regarding sizes, grades and inspection. They are too drastic for the minds of some inspectors, causing rejection instead of classification at a lower grade for ties on account of defects.

From my observation on both the buying and selling sides during the past fifteen years, I consider that the old No. 1 and No. 2 specifications, in substance, are more generally used than the A.R.E.A. specifications. A good many railways say they use the latter, but in fact they inspect and grade the ties under the former. These A.R.E.A. specifications confuse size with quality. It has always been understood that No. 1 meant first quality and No. 2 second quality ties. It is regrettable, therefore, that the A.R.E.A. specifications designate the various sizes by numbers. The old way is preferable, giving the size (width and thickness) supplemented by the grade (No. 1, No. 2, or cull).

PROPOSED CLASSIFICATION OF RAILROAD TIES

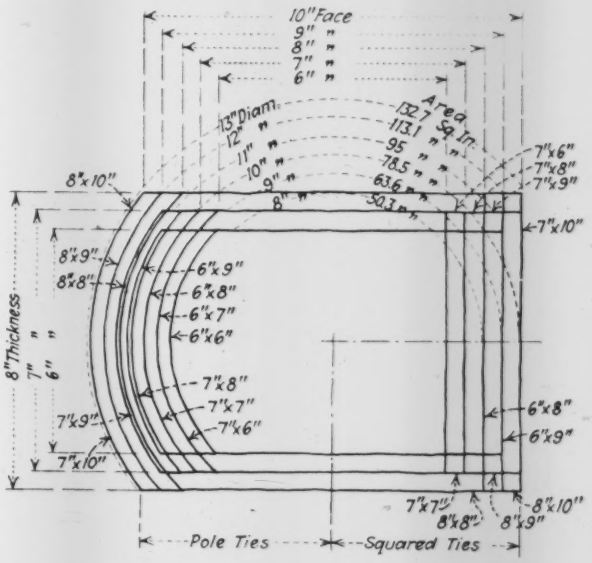
No.	Size of Tie — Thick In.	Face In.	Square or Pole	Cross Section Sq.In.	Classification; Standard*	A.R.E.A. Class
1	6	5	Pole	42.0	No. 2, 6x 8 in.	None
2	6	6	Pole	46.3	No. 1, 6x 8 in.	No. 1
3	6	8	Square	48.0	No. 1, 6x 8 in.	No. 3
4	7	7	Square	49.0	No. 1, 6x 8 in.	No. 2
5	6	7	Pole	51.5	No. 1, 6x 8 in.	No. 2
6	6	9	Square	54.0	No. 1, 6x 8 in.	None
7	7	6	Pole	55.7	No. 1, 6x 8 in.	None
8	7	8	Square	56.0	No. 1, 7x 8 in.	No. 4
9	6	8	Pole	56.2	No. 1, 7x 8 in.	No. 3
10	6	9	Pole	62.6	No. 1, 7x 8 in.	None
11	7	9	Square	63.0	No. 1, 7x 9 in.	No. 5
12	7	7	Pole	63.7	No. 1, 7x 9 in.	No. 3
13	8	8	Square	64.0	No. 1, 7x 9 in.	None
14	7	8	Pole	69.5	No. 1, 7x 9 in.	No. 4
15	7	10	Square	70.0	No. 1, 7x10 in.	No. 6
16	8	9	Square	72.0	No. 1, 7x10 in.	None
17	7	9	Pole	75.3	No. 1, 7x10 in.	None
18	8	10	Square	80.0	No. 1, 8x10 in.	None
19	7	10	Pole	80.8	No. 1, 8x10 in.	No. 6
20	8	8	Pole	83.9	No. 1, 8x10 in.	None
21	8	9	Pole	88.3	No. 1, 8x10 in.	None
22	8	10	Pole	94.8	No. 1, 8x10 in.	None

*In standard classification, the 6x8-in. group in the first line is classed as No. 2. All the other groups in that column are classed as No. 1. The acceptance of No. 2 ties is to provide an outlet for such ties of this grade as it is necessary to take as a by-product incident to the economical purchase of No. 1 ties, rather than to encourage the use of small or defective ties. In the classification of ties with defects, those in the first line, 6x8-in., are "culls;" all the others are "No. 2 or cull."

Railroads today require on the average a better and a larger tie than in the past. But the effect on timber utilization is evident and demands consideration. For example, what profitable use can be made of a rejected tie having a small rotten spot; or what is to be done with that part of the tree which will yield only the small-size tie, as it is increasingly difficult to get rid of ties 6x6-in. and 6x7-in. to electric lines and industrial concerns. The A.R.E.A. specifications are wasteful in rejecting ties "if decayed in the slightest degree," but, fortunately, most of the railways do not adhere strictly to that requirement.

Ties should be classed according to the cross-sectional area, and it is a waste of timber to require ties to be hewed or sawed on four sides in order to save cost of transportation. Thus, it is not fair to the producer to classify a 7x7-in. pole tie, 63.7 sq.in., with a 6x8-in. squared tie with only 48 sq.in. of cross-sectional area. The former should be classed with a 7x9-in. squared tie, 63 sq.in. This condition is shown by the accompanying table and diagram. I would classify the ties according to their dimensions as given in the table.

The grouping of timbers by species, included in the A.R.E.A. specifications, is superfluous. In the early



COMPARISON OF POLE AND SQUARED TIES

days of wood preservation it was observed that some species of hardwoods were more resistant to treatment than others and it was thought that by the grouping of various species a more uniform penetration and absorption could be obtained. The writer, who was then general tie agent of the New York Central Lines, west of Buffalo, collaborated with the late C. B. Lowry, inventor of the Lowry process for timber treatment, in separating the various species into five groups. In January, 1908, that grouping was incorporated in the specifications of the New York Central Lines. That was the first attempt on record for grouping various species of woods for treatment in the same cylinder charge. But after many years of experience the writer came to the conclusion that it was not practical, in all cases, to separate various species in groups at points of shipment. When separation is necessary, it should be done at the treating plant, which is the common practice today.

The original purpose which the grouping was intended to accomplish is apparently disregarded by including in the same group species having very dissimilar penetrability; also some species, such as cedar and chestnut, that are durable without treatment and for that reason and because they are comparatively soft woods are seldom treated. Furthermore, the separation of ties into "sap" and "heart" is impractical with oak, locust,

walnut, larch, cedar, cypress, redwood, chestnut, sassafras, mulberry and other species. Only southern yellow pine and Douglas fir ties are occasionally so separated.

This grouping is also a hindrance to the treatment of white oak ties, for the designation implies that white oak should be used untreated. That was right ten or fifteen years ago, when that species was plentiful and when treating facilities were limited, but today white oak should be treated the same as all other hardwoods. In my opinion that part of the A.R.E.A. specifications relating to grouping of various species should be stricken out entirely.

The article by Mr. MacLean on life and renewal of ties, in *Engineering News-Record* of Aug. 26, 1926, p. 336, is of much interest, although I do not think the method is any more accurate or convenient than the curve presented by Miss Thorne in 1918. Yet I was glad to see it published in order to agitate the subject of the life of ties and indirectly to help the cause of wood preservation. I may add that my method of determining the life of ties, as published in *Engineering News-Record*, Dec. 26, 1925, p. 1034, has been approved and accepted by the Railway Presidents Conference Committee.

Arch Design Cheaper Than Girder for Road Undercrossing

Two Projects Estimated for Carrying Parkway Under a Four-Track Railway Line—Esthetic Treatment a Factor

By A. G. Hayden

Designing Engineer, Westchester County Park Commission, Bronxville, N. Y.

DETAIL cost comparison of two widely different types of design became necessary in planning for a structure to carry the new Hutchinson River Parkway Drive in Pelham, N. Y., through the high, four-track railway embankment of the New York, New Haven & Hartford R.R. Maintenance of railroad traffic during construction presented one of the important problems of the case. However, the necessity for esthetic treatment of the structure was also a factor, since it led to more elaborate construction of the supporting masonry and provision for a stone-masonry mask or face on the sides of the girder bridge, with resultant increase of cost. A noteworthy feature of the case is that at first the majority opinion was strongly in favor of the plate girder design, on the score of both lower cost and cheaper and safer maintenance of traffic, while subsequently this attitude was reversed when it was shown that cost and construction procedure favored the arch.

The four-track main line of the New Haven crosses over the location of the new parkway on a high embankment, about 43 ft. to track level, consisting largely of rock fill. The problem was to cut through the embankment and construct a bridge to carry the tracks over the drive, at minimum cost. A 17½-ft. width of opening was required. Train service could not be interrupted, and obviously maintenance of traffic would be a major item of the undertaking, affected to a great degree by the type of structure selected.

In the study of the problem, two projects were most prominent, and strong difference of opinion developed as to their relative merits. Both were thereupon studied in detail with great care. The one project, contemplating a single-span plate-girder crossing with concrete trough floor and arch masonry face mask, was at first favored by the railway engineers; the other, calling for the construction of a two-hinged concrete arch with masonry facing, was favored by the engineers of the Westchester County Park Commission, which is making the improvement. As the railway will probably participate in the payment for the work, it was interested in the economy of the design, but perhaps its strongest concern was the continuity of traffic during construction.

Plate Girder Project—This project, as outlined, involved the following items of procedure:

(1) Excavating pits within braced sheeting for the concrete abutments of a deck plate girder bridge, the tracks being supported over the excavation by steel or timber beams.

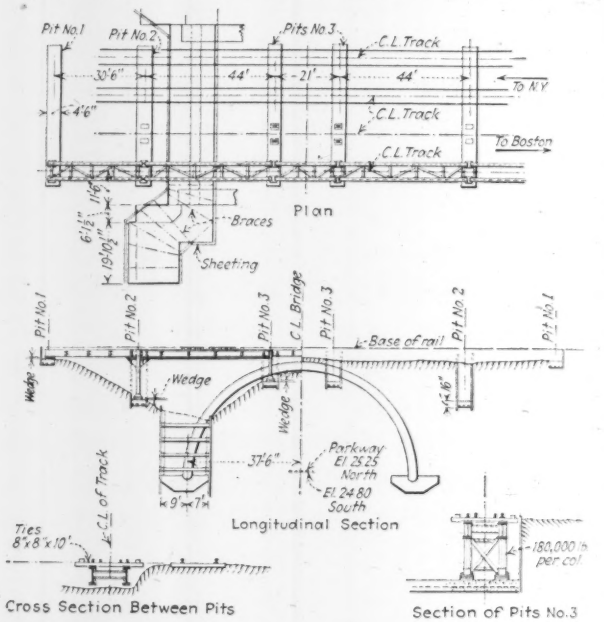


FIG. 1—TRAFFIC MAINTENANCE DURING ARCH CONSTRUCTION

(2) Constructing the concrete abutments.

(3) Building the bridge superstructure in four single-track units, each complete with concrete trough floor and tracks, two units on either side of the railroad embankment, on temporary timber bents adjacent to the permanent bridge seat.

(4) Diverting traffic temporarily from the two northbound tracks to the two southbound tracks (or vice versa), removing the abandoned tracks, excavating to the proposed elevation of the bottom of the girders, and rolling each unit of the new bridge laterally into place on the abutments, followed by connecting up the tracks and opening to traffic.

(5) Repeating the process for the other two single-track units of the new superstructure.

(6) Completing excavation under the bridge.

(7) Building the masonry arch facing.

Arch Design—This scheme, worked out and proposed by the engineering department of the Park Commission, included the following operations:

(1) Placing temporary girder supports under the four tracks to maintain traffic during construction.

(2) Excavating under the temporary supports to the line of the soffit of the arch.

(3) Excavating pits within braced sheeting for the construction of footings for a two-hinged concrete arch, followed by casting the footings within the pits.

(4) Erecting the stone arch facing and casting the arch rings.

(5) Completing the construction of the ornamental buttresses and boulder-faced wing walls.

(6) Completing the excavation under the finished arch, filling over the arch, removing the temporary track supports, and replacing the tracks in permanent position.

Comparison of Projects—In favor of the girder construction it was claimed that the structure and construction would be simpler and cheaper. As the temporary structure for supporting the tracks during construction would span only the width of the abutment pit, there would be less risk to traffic—assuming this risk to be in proportion to the track length of temporary construction—and correspondingly less cost for traffic maintenance. It was also claimed that the erection of the girder spans would be much simpler than casting the arch.

On the other hand, this project had certain obvious disadvantages. The girder bridge would be a sham, the stone arch facing demanded by the Commission for esthetic effect being a mask hiding the real structure, though the girder construction would show from beneath to users of the drive. The construction method presented the risk that unexpected delays might be encountered in making the partial excavation of rock fill after removing the old tracks and before sliding the girders into place. Any such delay might seriously affect train schedules.

Because of the large cost items that were in question under both projects, a detailed study was entered into. Careful cost estimates were prepared for all items, and underpinning experts were consulted as to the best methods for supporting the tracks and maintaining traffic. Moran, Maurice & Proctor, of New York City, were engaged to make the final study of this feature. Cost estimates for the arch bridge were made by the engineers of the Westchester County Park Commission. Cost estimates for the girder bridge were made by two railway companies and by the Commission, the three estimates agreeing very closely.

The results of these studies clearly proved the arch bridge to be preferable, on the score of both cost and continuity of traffic.

The preliminary estimates of cost for the two projects were placed at $290,000 for the arch project and $340,000 for the girder project, indicating a saving of 15 per cent through adoption of the arch design. Various features of the comparison of the projects may be stated:

(a) The cost of the two-hinged arch bridge was much less than the cost of the steel girder bridge.

(b) The procedure for constructing the arch and maintaining traffic was in all respects feasible and safe. The preliminary project had contemplated timber beams for the temporary track-carrying structure, but in the later planning steel was substituted. The carefully planned procedure satisfied the railway engineers entirely, so much so that they said it would not be necessary to issue slow-speed orders except for a few brief periods while installing the several units of the temporary track supports. Traffic would be maintained on all four tracks without diversion from one track to another.

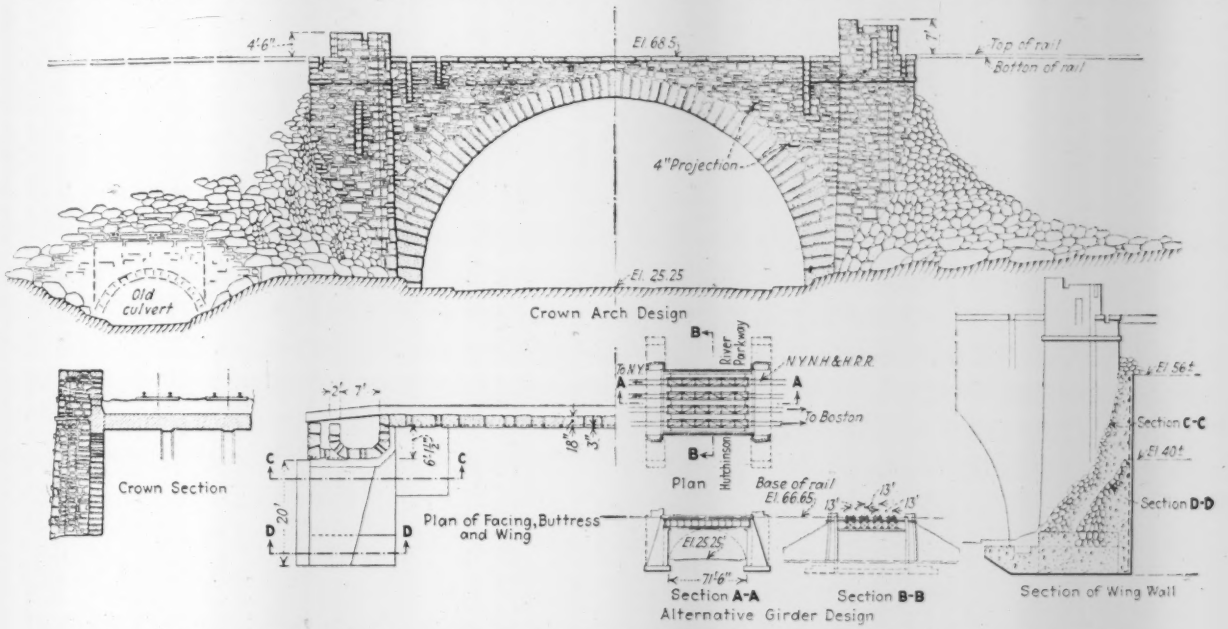


FIG. 2—COMPARATIVE DESIGNS FOR NEW HAVEN UNDERCROSSING, HUTCHINSON RIVER PARKWAY

(c) Operation 4 in the construction of the girder scheme was found on analysis to be more difficult and expensive than appeared at first sight, and would involve rather serious interference with traffic.

Thus all the advantages claimed for the girder scheme disappeared, and accordingly the arch design was agreed to by all parties.

Certain interesting details of the construction of the arch are shown in Fig. 3, particularly the hinge detail and the spandrel-wall design. Above the footings, the main structure is entirely free from the buttresses and wing walls, so that elastic deformation can take place freely. The footings of the arch will be extended to provide for future widening of the bridge, in order that

six railway tracks may be accommodated, if that should ever be necessary.

The structure was designed for a live-load of 14,400 lb. per linear foot of each track, including impact allowance. Working stresses of 18,000 lb. per sq.in. in the reinforcing steel and 800 lb. per sq.in. in the concrete were used in proportioning. The material of the arch barrel is to be 2,500-lb. concrete at 28 days.

So far as is known to the railroad engineers, this will be the first two-hinged concrete arch for railroad traffic in this country.

Computations were made and plans prepared under the immediate direction of R. M. Hodges, designer, Westchester County Park Commission, and were examined and checked under direction of P. B. Spencer, engineer of structures, New York, New Haven & Hartford Railroad Company. The bridge is part of an extensive development of parkway systems in Westchester County now going on under the direction of Jay Downer, chief engineer, and Leslie G. Holleran, deputy

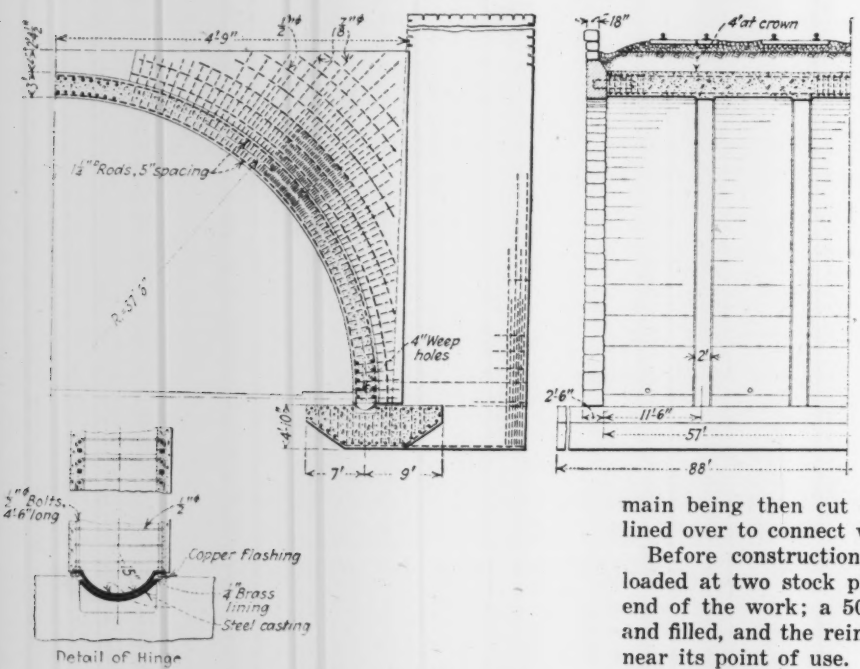


FIG. 3—STRUCTURAL DETAILS OF ARCH BRIDGE

chief engineer, of the Westchester County Park Commission, of which R. H. Macy, of New York City, is president. The park development is planned for both present and future requirements of the constantly expanding metropolitan district of New York City.

Conclusions should not be drawn from this article as to the best method of solving grade crossing eliminations in general. This particular problem was recognized at the outset as a special one, and the solution described herein was reached only after exhaustive analysis of all of the elements entering into the problem, including train schedules. Another grade crossing elimination which the commission is now studying, involving the construction of a four-track bridge to provide for two present and two future tracks, wil' be solved by a method similar in general to the girder method outlined above, although certain details of procedure will be modified to meet the particular existing conditions.

Building Concrete Roadbed for the Pere Marquette R.R.

Heavy Slab Has Steel Truss Reinforcement Under the Rails—Gravel Concrete Mix—Construction Methods

A STRETCH of main track having a reinforced-concrete slab to which the rails are secured directly, eliminating ballast and cross ties, has been put in actual service on the Pere Marquette R.R., following the design prepared about a year ago by Frank H. Alfred, president, and Paul Chipman, office engineer, as described in *Engineering News-Record* of Dec. 10, 1925, p. 958.

From the drawing, Fig. 4, it will be seen that a slab 10 ft. wide and 21 in. deep has two longitudinal steel frames consisting of posts of 3-in. channels, with a pair of angles 1½x1½-in. for the bottom chord and a pair of plates 4x¼-in., placed on edge, for the top chord. The rails are seated directly over this chord and are secured by clips with bolts passing through stirrups riveted to the sides of the chord plates.

Construction Plant and Methods—This section of concrete roadbed is 1,326 ft. long, composed of 34 slabs in 39-ft. lengths. As it required only about 850 cu.yd. of concrete, the construction plant was quite simple. The location is at Beech, 1½ miles west of the Detroit city limits, on the westbound track of the line to Grand Rapids. A passing track afforded opportunity for diverting eastbound traffic during construction, the westbound main being then cut near each end of the work and lined over to connect with the former eastbound track.

Before construction began, the aggregate was unloaded at two stock piles, each about 330 ft. from an end of the work; a 500-barrel cement house was built and filled, and the reinforcing material was distributed near its point of use. A ½-yd. steam-operated concrete mixer was installed at the west stock pile, water being obtained by piping from a city main about ½-mile distant. Concreting began at the west end after a section of the subgrade had been prepared and forms and steel work set up. The subgrade was prepared by taking out the ballast above the bed of the old ties, finishing to a true surface and grade and covering with a ¾-in. layer of mortar. When this had hardened it was covered with ½-in. of fine sand to insure a plane of cleavage in case it should ever be necessary to lift the slab on account of settlement. The pebbles and sand which formed the aggregate were wheeled to the mixer, and the concrete was distributed in two-wheeled concrete carts.

Concrete and Forms—Aggregates consisted of washed sand graded from ¼-in. down, and washed pebbles ranging from ¼ in. to 1½ in. The water cement ratio was used in proportioning for a strength of 4,000 lb. per square inch at 28 days. A consistency that would give a slump of 3 to 4 in. was the aim, resulting

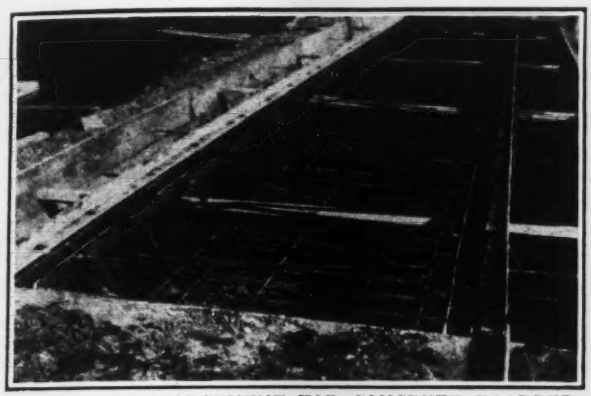


FIG. 1—REINFORCEMENT FOR CONCRETE ROADBED

in a concrete which would readily settle to place around the reinforcement and yet bring practically no surplus water to the finishing surface.

The forms, of 2-in. pine, were made in 13-ft. sections, three sections on each side being required for a slab. These were set to line and grade and braced on the outside, and were further prevented from spreading by ¼-in. steel ties with adjustable clamps. End forms for each 39-ft. slab consisted of galvanized iron separators, so formed as to make a horizontal 2½x6½-in. tongue and groove joint between slabs, to prevent unequal settlement at the joints. These end forms were held in place temporarily with wooden stakes and braces.

Placing Reinforcement and Rail Supports—Stakes were driven to proper elevation for subgrade at intervals of 6 ft. to support the light trusses which are directly under the rails. These trusses were set up, connected together with the cross-braces and tie-rods, and adjusted to proper gage. The stirrups for attaching the rails were then bolted on, and the longitudinal and transverse reinforcing was wired in position. To insure proper alignment of the bolts which attach the rail clips to the stirrups, a 3x3-in. angle with bolt holes at proper intervals was bolted on top of the stirrups, in place of

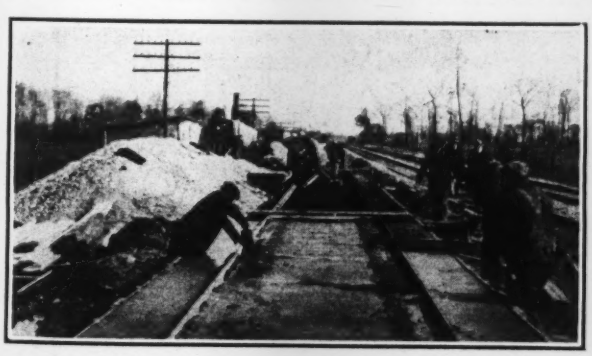


FIG. 2—SURFACING THE CONCRETE
Steel angles bolted temporarily in place define the rail seats.

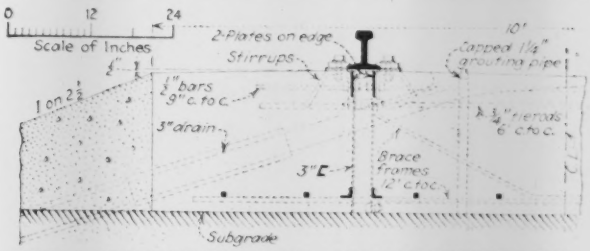


FIG. 4—CONCRETE ROADBED; PERE MARQUETTE R.R.

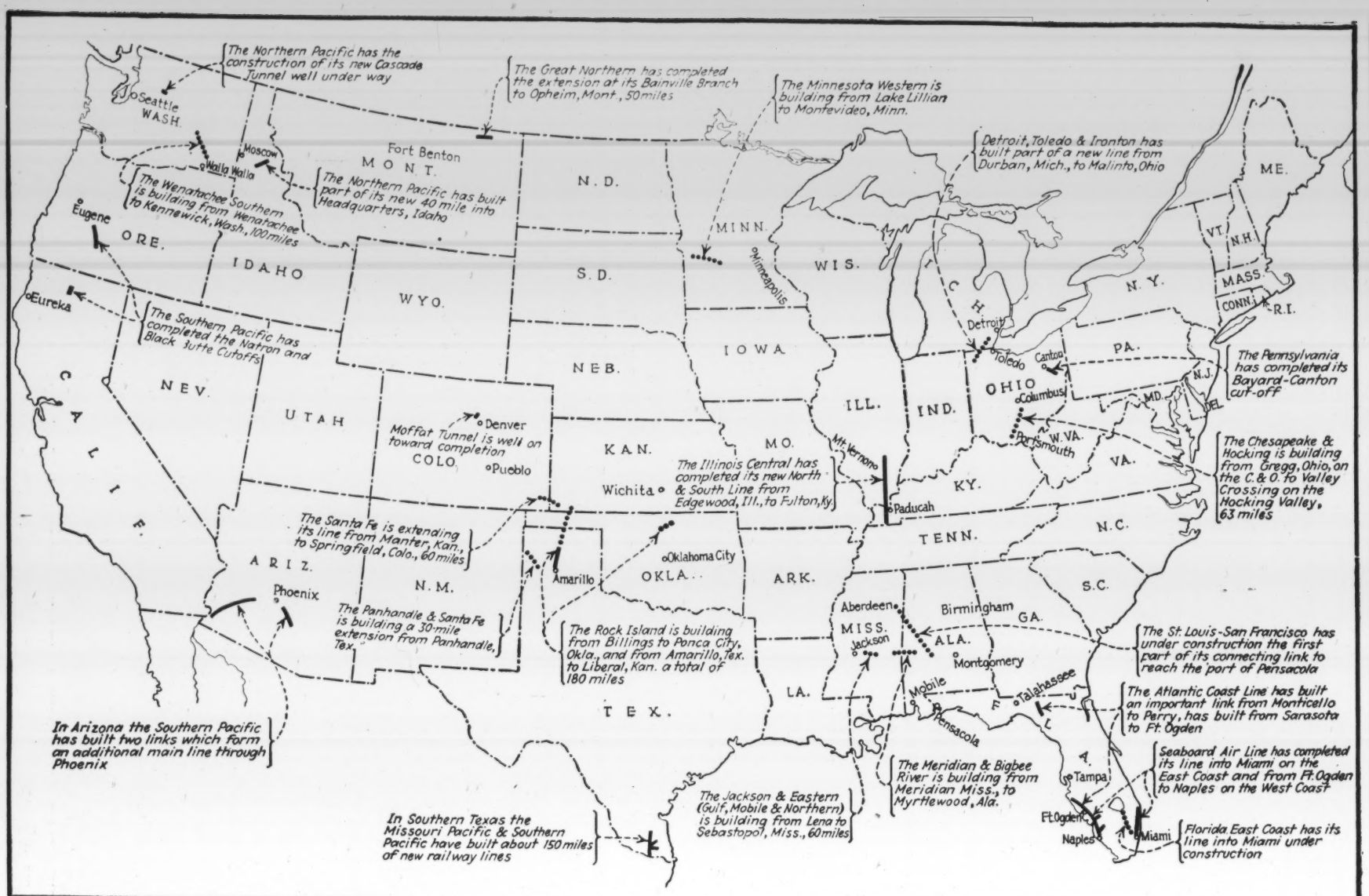
the rail, and was carefully checked for line and grade with transit and level while the concrete was being placed. These angles are shown in Fig. 2.

Placing and Finishing Concrete—The concrete carts were wheeled on runways and dumped from a movable platform over the middle of the slab, the concrete being tamped about the reinforcement and trusses with shovels, wooden rods and the rubber boots of the workmen. The finishing of the surface was done with a strike-off board and float, except at the rail seats, where special care was taken and a trowel was used to secure a smooth finish in a true plane. When the surface was finished it was covered with wet sandy loam for a week.

FIG. 3—COMPLETED SLAB AND TRACK

Laying Rails—Before rail laying was begun, any small irregularities were removed from the rail-seat by rubbing them down with carborundum bricks and water. A coat of asphalt paint was then applied to the rail-seat, after which it was covered with 5-ply insulation in strips about ⅛ in. thick and 5½ in. wide. When the rails were in position, the rail clips were assembled with their insulation and bolted down, a spring washer being placed under the head of the bolt.

No provision is made for any adjustment of the rail as to surface independently of the slabs, although shims of limited thickness could be inserted under the rail if necessary. If any considerable settlement should occur, a slab can be lifted with jacks and grout forced under it by compressed air, either from the side or through the vertical pipes set in the concrete for that purpose. Minor adjustments of line can be made by setting new rail clips with bolt holes at new positions in the rail. A 3-in. drain is formed diagonally in each slab. Gravel ballast is filled in against the concrete roadbed and sloped 1 on 2½ to the subgrade.


The Northern Pacific has the construction of its new Cascade Tunnel well under way
The Great Northern has completed the extension at its Bainville Branch to Opheim, Mont., 50 miles
The Minnesota Western is building from Lake Lillian to Montevideo, Minn.
Detroit, Toledo & Ironton has built part of a new line from Durban, Mich., to Malinto, Ohio
The Wenatchee Southern is building from Wenatchee to Kennewick, Wash., 100 miles
The Northern Pacific has built part of its new 40 mile into Headquarters, Idaho
The Southern Pacific has completed the Natron and Black Butte Cutoffs
Moffat Tunnel is well on toward completion
The Illinois Central has completed its new North & South Line from Edgewood, Ill., to Fulton, Ky.
The Santa Fe is extending its line from Manter, Kan., to Springfield, Colo., 60 miles
The Panhandle & Santa Fe is building a 30-mile extension from Panhandle, Tex.
The Rock Island is building from Billings to Ponca City, Okla., and from Amarillo, Tex. to Liberal, Kan. a total of 180 miles
In Arizona the Southern Pacific has built two links which form an additional main line through Phoenix
In Southern Texas the Missouri Pacific & Southern Pacific have built about 150 miles of new railway lines
The Jackson & Eastern (Gulf, Mobile & Northern) is building from Lena to Sebastopol, Miss., 60 miles
The Meridian & Bigbee River is building from Meridian Miss., to Myrtlewood, Ala.
The Pennsylvania has completed its Bayard-Canton cut-off
The Chesapeake & Hocking is building from Gregg, Ohio, on the C. & O. to Valley Crossing on the Hocking Valley, 63 miles
The St. Louis-San Francisco has under construction the first part of its connecting link to reach the port of Pensacola
The Atlantic Coast Line has built an important link from Monticello to Perry, has built from Sarasota to Ft. Ogden
Seaboard Air Line has completed its line into Miami on the East Coast and from Ft. Ogden to Naples on the West Coast
Florida East Coast has its line into Miami under construction
Seattle
Wash.
Moscow
Walla Walla
Fort Benton
Mont.
N. D.
Minn.
Minneapolis
Wis.
Mich.
Eugene
Ore.
Idaho
Wyo.
S. D.
Eureka
Nev.
Utah
Neb.
Iowa
Ill.
Ind.
Ohio
Detroit
Toledo
Canton
Columbus
Pa.
N. Y.
Me.
Vt.
N. H.
Mass.
Conn.
R. I.
N. J.
Md.
Del.
W. Va.
Portsmouth
Va.
Ky.
Mt. Vernon
Paducah
Tenn.
N. C.
S. C.
Ga.
Ala.
Miss.
Aberdeen
Jackson
Birmingham
Montgomery
Mobile
Pensacola
Talahassee
Tampa
Ft. Ogden
Naples
Miami
Fla.
Denver
Colo.
Pueblo
Kan.
Wichita
Mo.
Oklahoma City
Okla.
Ark.
La.
Tex.
Amarillo
Ariz.
Phoenix
N. M.
Calif.

Major Railroad Projects Completed or Under Way During the Past Year

Completed work is shown in solid lines; work under construction or contracted for is shown dotted. New second tracks and lesser projects are not shown.

Relocation Reduces Grades from 6 Per Cent to 3 Per Cent

Heavy Traffic on Mountain Railroad Necessitates Grade Reduction to Increase Traffic Capacity—Switchback at Mines

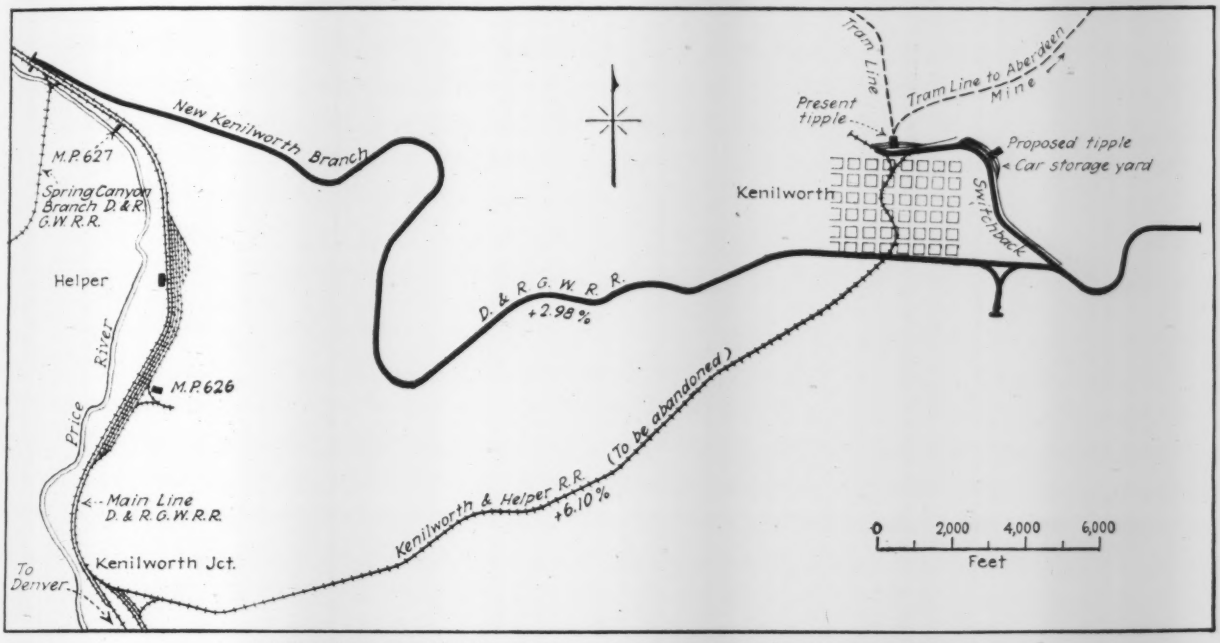
DIFFICULT LOCATION and heavy rock excavation for grading are involved in the reconstruction of the Kenilworth branch of the Denver & Rio Grande Western R.R., in Utah, by which the original maximum grade of 6.1 per cent has been reduced to 3 per cent. In the rough and broken mountainous country such a favorable relocation seemed almost impossible, but the great increase in traffic made it imperative that the problem should be solved, since the output of mines served had reached the limit of traffic capacity on the original line.

Several years ago when the Independent Coal & Coke Co. opened the Kenilworth mine, about four miles east of Helper, Utah, a standard-gage railroad to the mine was constructed by the coal company, having a junction with the Denver & Rio Grande Western R.R. main track at a point just beyond the east end of the yard at Helper. This line, known as the Kenilworth & Helper R.R., is 3.74 miles in length, with maximum grades of 6.10 per cent and a maximum rate of curvature of 10 deg. The elevation of the junction is 5,780 ft. and the elevation at the Kenilworth mine is 6,604 ft., thus producing an average grade of about 4.2 per cent without compensation for curvature. For seven years the line was operated by the coal company, using geared locomotives, but in 1914 the road, with its equipment, was leased to the Denver & Rio Grande Western R.R., which has operated it since that time.

A tonnage train to the mine for two geared locomotives coupled together consists of thirteen empty cars, while the same number of loaded cars is the maximum permissible train load descending from the mine. The production of the Kenilworth mine has increased steadily and recent plans of the coal company contemplate still further increase in production by a new opening known as the Aberdeen mine, adjacent to the Kenilworth and at about the same elevation. The combined capacity production with the large modern colliery facilities proposed for the Aberdeen mine will amount to 5,000 tons per day, or 100 carloads of the average 50-ton capacity cars. A tonnage traffic of this magnitude is entirely beyond the operating capacity of the present Kenilworth & Helper R.R., while even half that tonnage imposes difficulties and operating expenses incommensurate with the revenues.

Under these circumstances it was decided to build a new line on such grades as to give an operating capacity sufficient for the entire ultimate production of the Kenilworth and Aberdeen mines and for any reasonable increase resulting from the opening of additional mines in the immediate vicinity. This line, shown in the accompanying plan and now under construction, is 6.28 miles in length, including about a mile of switchback line to serve both mines in setting in empties and taking out loads. The switchback line is constructed with a maximum grade of 1.65 per cent, heavier grades being impracticable in the gravity operation of tipple and storage tracks, space for which is at a premium. From the junction to the switchback there is a continual rise, with grades ranging mainly from 2 to 3 per cent.

The new branch diverges from the main line of the Denver & Rio Grande Western R.R. near the west end of the yard at Helper, and thence extends in an easterly direction over rough and broken country by means of a 3 per cent supported grade line compensated for curvature, of which the maximum rate is 10 deg. The formidable territory traversed lies immediately under high sandstone cliffs and is strewn with immense boulders and fragments of the stratified material of which the cliffs are constituted. Such timber as is



RAILROAD RELOCATION IN UTAH: DENVER & RIO GRANDE WESTERN

encountered along the line consists of scraggly red cedar in moderately thick stands.

The alignment is severe, with a large aggregate amount of total angle, owing to the ruggedness of the country and the necessity of employing a supported grade line. The profile is deeply serrated, with some large cuts and fills. Steep slopes along which the line is built add large quantities to the excavations and embankments, not indicated by the center-line profile. The material consists of moderately heavy classification, the solid rock being largely boulders and hard blue shale.

Owing to the difficulty of close classification of the materials, the contract was let for a unit price of excavation without classification, a price for borrow, and a price for overhaul beyond a limit of 500-ft. free haul. Construction of reinforced-concrete box culverts, mass concrete headwalls for pipe culverts, and placing of the culvert pipe were included in the contract for grading. This contract, awarded April 6, 1926, involved the handling of about 500,000 cu.yd. of material, and since it had to be completed to permit finishing the track work before the season of inclement weather, a large amount of construction equipment was employed. Although the line to be constructed lay within four miles from the operated line, yet because of the extreme roughness of the country traversed, great difficulty was experienced in getting steam shovels and equipment to different parts of the work. Considerable time was consumed also in laying pipes on the heavy sections of the line to supply water and compressed air for prosecution of the work. There are eight units of shovel equipment with narrow-gage engines, cars, and dump wagons on the job, and several of these units have been worked on double shifts.

Owing to the difference in elevation of the new and old lines at their intersection, which difference was too great to permit a grade crossing or temporary connection and too little to permit an undercrossing of the old line, and owing also to the necessity of serving the Kenilworth mine without interruption, that portion of the new track above its crossing with the old line will have to be laid from the Kenilworth end, while that portion below the crossing will be laid from the main line end, the two being connected and put into service immediately on cutting the old line at the point of crossing. The difference in elevation of the new and old tracks at Kenilworth also requires temporary switches to avoid delay in operation of the mine while change in train service is being made from the old to the new line. A wye at Kenilworth and a convenient layout of the coal company's tipple and storage tracks with track scales and crossovers complete the transportation facilities, so that full tonnage trains both of empties up and loads down can be moved with ordinary locomotives at minimum expense.

Surveys—In such difficult mountain country it is not practicable to make a definite and final location with one survey. Ordinarily it requires a preliminary line which, according to the judgment of the locating engineer, is more or less closely followed in the final location. This preliminary is an angle line only, and if a supported grade is necessary, the line is kept close to the grade elevation. Topography is taken along the preliminary line and a projected location made from a topographical contour map. In heavy mountain construction, also, it is usually impossible to fit the location to the country so as to produce the most economical results. By projecting a location on the topographical map, the many attempts in fitting the line in the field are avoided and much expense is therefore eliminated. The projected location is followed in the final field location, but modified and improved as circumstances warrant. In this particular case there was no question of the economic value of reconstruction, since the traffic capacity of the old line was actually insufficient. Local circumstances and topographic conditions determined the 3 per cent grade for the new line.

This relocation and reconstruction work was done under the direction of Arthur Ridgway, chief engineer of the Denver & Rio Grande Western R.R., with L. O. Doane as engineer in charge. The contract for roadbed complete, ready for tracklaying, was awarded to the Utah Construction Co., Ogden, Utah, the tracklaying being done by railroad forces.

Shield Safeguards Train Movements in Tunnel Replacement

Rectangular Concrete and Steel-Beam Structure Replaces Horseshoe Section Brick Arch Passing 260 Trains Daily

BY CHARLES CARSWELL
Washington, D. C.

IN its program for new terminal facilities in Philadelphia, the Pennsylvania R.R. has recently reconstructed its passenger train tunnel under 32nd St., between Market and Chestnut Streets. The work was handled without interruption of train service, about 260 trains a day, by means of a traveling shield constructed as shown by Figs. 2 and 3.

The old tunnel, built about 1864-66, was of horseshoe

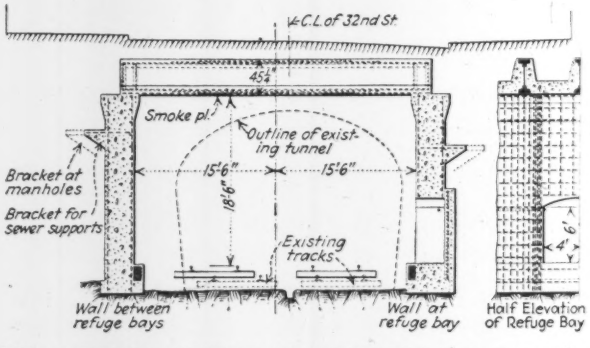


FIG. 1—TYPICAL SECTION OF RECONSTRUCTED RAILWAY TUNNEL UNDER 32ND ST., PHILADELPHIA

section, with a brick arch roof. The new tunnel, Fig. 1, is of rectangular section and is constructed of reinforced concrete and steel. The tracks have been elevated slightly to improve operating conditions at the north, immediately beyond the tunnel, and a clearance of 18 ft. 6 in. has been provided from the top of rail to the bottom of the roof slab. At the south end of the tunnel these clearance requirements bring the roof close to the street surface, a minimum of 3 ft. from grade to bottom of tunnel roof. For this section 24-in. I-beams, spaced 2 ft. 9 in. on centers, were used. As the surface grade becomes farther above the roof of the tunnel, 30-in. beams, spaced 4 ft. 6 in. on centers, are used, and with greater clearance toward the north, 36½-in. plate girders spaced 6 ft. on centers.

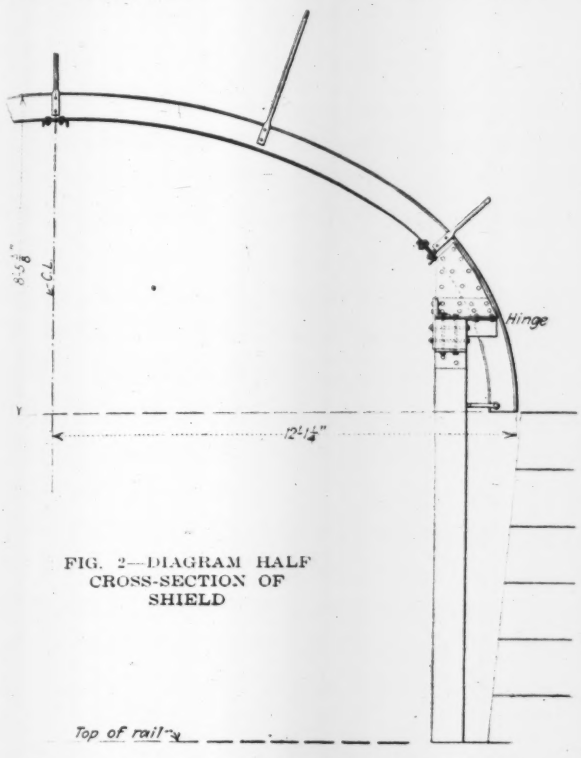


FIG. 2—DIAGRAM HALF CROSS-SECTION OF SHIELD

The requirements for maintaining traffic during the work and the irregularities of the arch section led to the development of the special shield for protecting the tracks from debris. This shield consisted of a frame of 8-in. I-beams, covered with ¼-in. steel plates and braced longitudinally with 8-in. channels, the shield being shaped to the average section of the brick arch.

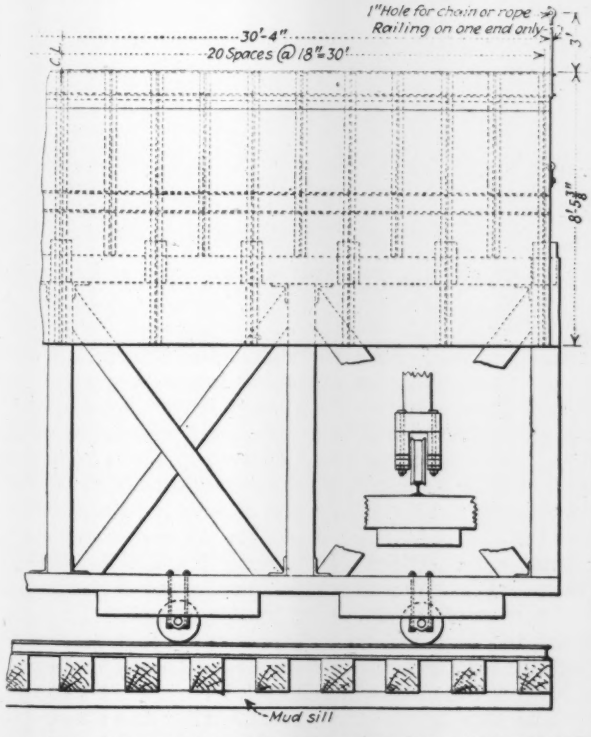


FIG. 3—DIAGRAM HALF SIDE ELEVATION OF SHIELD

The shield spanned the entire width of the old tunnel and was supported by a timber frame on trucks operated on a single rail at each side of the tunnel. In order to provide clearance for railway equipment, the tracks were moved close together, 6 ft. on centers, making in effect a gauntlet track construction in the tunnel during the work, the entrance of trains being controlled by semaphores at each end. With the trucks of the shield frame resting on their supporting rails, the shield was below the points of minimum clearance of the brickwork. In addition, wings, or aprons, were provided on the shield, which were dropped down when the shield was to be moved, providing lateral movement to secure additional clearance. When the shield had been advanced to the desired position, the wings were lifted and the supporting frame was jacked up from the rails, bringing the shield into contact with the brick masonry and affording the greatest possible clearance in the tunnel.

Except for the portions of Market and Chestnut Streets which were underpinned, excavation and the placing of steel and concrete were handled by equipment operated directly over the tunnel. For it, the contractor provided timber platform on steel girders. The girders were part of those required for the permanent roof of the new tunnel and were furnished long enough to span to temporary supports beyond the side walls of the completed tunnel, the excess length being subsequently burned off.

The roof formwork presented special problems because of the necessity of bracing without shoring. The contractor braced the forms against the roof by the use of inclined struts, or rakers, bearing against the vertical posts of the wall forms, and at the roof against a central timber strut attached to the bottom of the roof beams used for the support of the construction equipment. This method of bracing provided the necessary rigidity of forms without obstructing the clearance in the tunnel.

The tunnel was designed and constructed under the supervision of the engineering department of the Pennsylvania R.R., A. C. Shand, chief engineer, H. R. Leonard, chief engineer of bridges and buildings, and Robert Farnham, engineer of bridges and buildings. The Keystone State Corporation, Philadelphia, Pa., was the contractor.

Railway Construction in 1926

New railway construction in 1926 aggregated 1,005 miles, distributed through 29 states, according to the annual statistics of *Railway Age*. This was 361 miles more than in 1925, and was the highest record since 1916, when 1,098 miles were built. In individual states, Texas ranks first with 242 miles; Florida had 233; Arizona, 146 miles; and then a drop to Nevada with 72 miles and Oklahoma, 55½ miles. Double-tracking was less active, totaling 473 miles, or 209 miles less than in 1925. Third and fourth tracks aggregated only 29 and 20 miles respectively. The total of first and multiple main tracks laid was 1,527 miles, as against 1,354 in 1925. Abandonment of railways decreased from 606 miles in 1925 to 457 miles in 1926; it included mainly short branch lines abandoned on account of highway motor traffic competition or of exhaustion of timber and mineral resources which the lines were built to serve. In Canada, the length of new lines built was 335 miles, and 72 miles were abandoned. In Mexico, railway extension totaled only 28 miles.

Fighting Snow on a Mountain Railway in Norway

Permanent High Snow Screens Used to Divert Snow from Track or to Cause Prevailing Winds to Blow Track Clear—Snowsheds Built to Withstand Great Snow Loads

By R. Lorange
Division Engineer, Norwegian State Railways, Drammen, Norway

THE railway from Oslo (Christiania) to Bergen on the west coast of Norway crosses the mountainous central part of the country and is unique among the mountain railways of the world in that it attains an altitude of 1,300 meters (4,300 ft.) at 60 deg. northern latitude and for a distance of about 100 km. (64 miles) is situated above the tree line. When it is added that the western part of the line, ascending the steep coast mountains of Norway, faces the North Atlantic and is exposed to the sudden and violent storms coming from that ocean, it will be readily understood that the climatic conditions along the railway are very severe and that the traffic difficulties arising from the heavy snowstorms during the winter, which in the mountains lasts about nine months, are most serious.

The precipitation on the western and central parts of the line is very heavy, and most of it falls as snow. The snowfall in itself is not so dangerous, however, as the frequent high storms which sweep the snow along the ground and cause the accumulation of immense snowdrifts. On sidehills and in cuts, drifts 25 to 30 ft. deep are by no means rare, and on the plateau just east of the summit an even snow cover of 15 to 20 ft. depth is quite frequent.

Fighting the snow and keeping up traffic the whole year round form a difficult task that requires, beside a large and picked personnel, active and passive means of defense. The former consists of engine-front plows, rotary plows and snow scrapers; the latter, snow screens, snowsheds and, as protection against avalanches, masonry arches over considerable stretches of the line.

Personnel—For maintenance-of-way purposes as well as for snowfighting, the mountain division, which is 115 km. long, is divided in sections of about 6 km. (3.7 miles) each. On each section are one foreman and three trackkeepers in permanent positions and a variable number of extra men, generally from three to five. During the short summer season, upwards of 100 carpenters are employed in repairing and rebuilding broken down snowsheds and screens.

The division engineer is assisted by two roadmasters and four plowmasters and is stationed at the station of Finse at 1,222 m. altitude. Finse is 10 km. east of the summit, facing the large Hardanger Glacier in the center of the mountain division, and is the chief depot station for the snow-fighting forces. Here are stationed two rotary plows, from two to four heavy engines, besides snow scrapers and plows with movable wings. The force of plow machinists, engine drivers, firemen and oilers numbers from 25 to 30, and an equal number of shovelmen are employed at Finse during the winter. At Myrdal, situated 35 km. farther west at 860 m. altitude, is another depot station with two rotary plows etc. but a somewhat smaller number of personnel.

Through frequent rides over the division as well as through telephone reports from the trackmen, the division engineer keeps himself constantly acquainted with the state of the snow conditions on the line; weather predictions cabled from the weather bureau at Bergen give warnings of coming storms. The division engineer decides when snow-fighting trains are to take the field

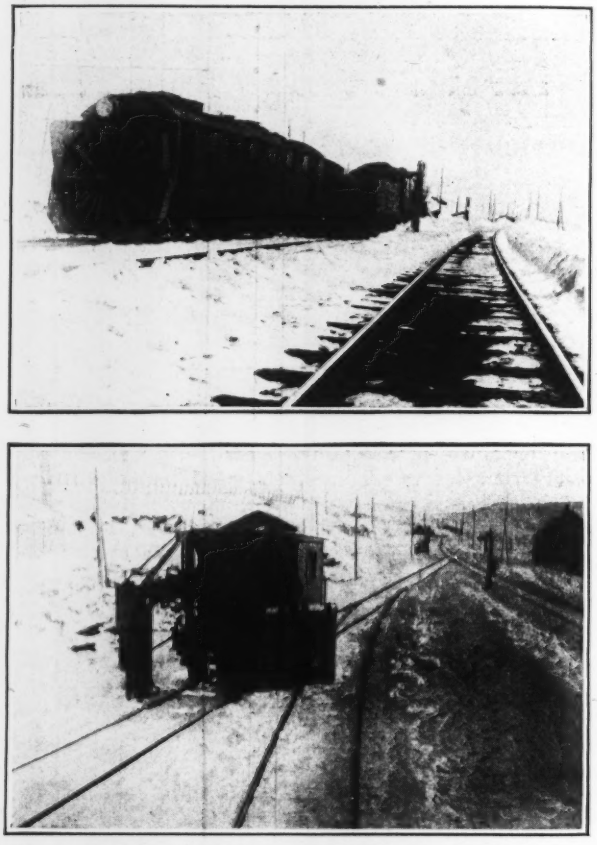


FIG. 1—ABOVE, ROTARY SNOW PLOW. BELOW, SCRAPER FOR WIDENING SNOW CUTS

and draws up their schedules in conference with the train dispatcher. He also decides when through trains are to be kept back, giving the line to the plow trains.

Snow Plows—The engine-front plows employed on the mountain division are of a very heavy and substantial type. From a certain point of time at the commencement of winter, according to the judgment of the division engineer, no train or idle engine is permitted to pass the mountain division without the engine carrying a front plow. These plows are very effective. When the train is running at a good speed, snow drifts up to 5 ft. deep are tackled without trouble, provided the drift is not too hard packed by storm or through moisture from thawing and the snow cut is not too deep. In the latter case the snow will roll back from the sides of the cut and pack around the wheels. When the snowdrift is long, this packing increases the train resistance and might block the train and thus the line.

The rotary plows, shown in Fig. 1, have from 1,200 to 1,500 horsepower capacity, all on the fan axle, none of the plows being self-propelled. The fan wheel has a diameter of 3 meters, the shield being one-half meter wider on each side. The plow rides on 6 axles, each

FIG. 2—SCRAPER FOR PLATFORMS

with 14 tons axle load, and is pushed by one or two heavy engines. The plow engine is a 4-cylinder high pressure engine, with maximum of 150 r.p.m.

When driving the rotary plow through deep snowdrifts, the perpendicular snow walls on each side form a narrow cut, scarcely wider than the rolling stock. As the snow accumulates with each snowfall, the walls soon grow so high that the engine front plows are not able to throw the snow over the edge. A widening of the cut therefore becomes necessary to give room for this snow, for which work snowscrapers are employed. The scraper which is shown in Fig. 1 is a flat car drawn by an engine and provided with two powerfully built movable steel wings 6 ft. high which when opened form an angle of 45 deg. with the direction of driving. Each wing is moved independently through a winch on each side in the deck house. The wings embrace a width of 5.5 meters and cut the snow loose from the cut walls, gathering it in toward the middle of the track where it is left lying as a high bank, to be removed by the following rotary plow.

Station platforms are cleaned by another type of scraper with only one wing of 5 meters length, Fig. 2.

Snow Screens—Although the above mentioned snow cleaning machines are very efficient the line could not be kept open and traffic kept up in winter without protective works of the most substantial construction.

On the eastern slopes of the mountains, where the precipitation is more moderate and the valleys are comparatively wide and flat, snow screens are employed.

As shown in Fig. 3, the snow screens are from 4

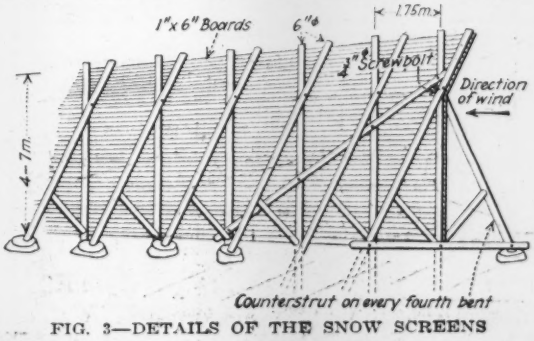


FIG. 3—DETAILS OF THE SNOW SCREENS

to 7 m. (13 to 23 ft.) high [consequently "snow fences" would not be an appropriate appellation], and built of 1-in. boards on bents of sticks of 6-in. top diameter; the distance between bents is 1.75 to 2 m. The function of the screens is not to gather the snow about themselves but to guide the drifting snow away from the line. If the disposition of a screen is wrong, it is apt to do great damage gathering or guiding the snow into the track.

Screening a certain stretch of line requires a close study of the direction of prevalent winds and the most frequent drift formations. No fixed rules can be given, only trials and experience can decide the disposition of the screens as to place, direction, length and distance from the track. Continuous screens paralleling the track are seldom or never to be recommended as they generally bury themselves in snow during one or two storms, and afterward they often cause great trouble

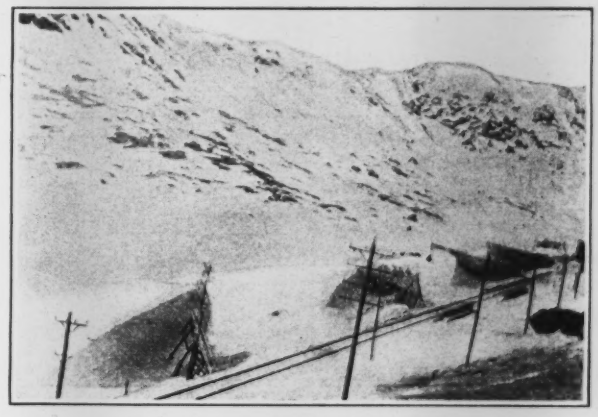


FIG. 4—A SYSTEM OF SHORT SCREENS
Note large snowdrifts at rear end of screens while windward side of near end is free of snow.

in building up great snowdrifts in the track. The screens are generally divided in wings of not more than 100 m. length, placed in series and slanting away from the line; the windward end may come as close as 10 to 15 m. from the track, the wing forming an angle of about 25 to 30 deg. with the direction of the most prevalent wind. See Fig. 4.

Screens can do efficient work only for one direction of wind and must be disposed accordingly. For opposite wind directions, the screens will guide driving snow in toward the line and may thus do much damage. If a stretch of line is exposed to strong winds and precipitation from several different directions, efficient screening of that stretch is difficult or impossible. In Fig. 6 is a schematic sketch of some screen systems.

When the line is situated in a narrow valley or canyon or in a steep sidehill, effective screening is rarely feasible as such country is exposed to more or less perpendicular heavy fall winds of indeterminable direction.

A successfully disposed screen system will help the wind to blow the track nearly clean of snow; the windward ends of the screens will also keep free. The wind eddies will screw along the slanting screen forming an open groove along the windward side, carrying the snow into drifts that form toward the rear end of the screen and continue as spurs into the open ground.

In the spring the snow contains much moisture and is apt to slide along sloping ground, bringing a heavy

pressure to bear on screens. To resist this pressure substantial struts and good foundations are necessary. Still, many screens are more or less overturned and crushed each year, necessitating much repair work. In the autumn when little or no snow surrounds the screens, heavy winds also do considerable damage.

Portable screens, made in sections 2x2 m., are used for secondary purposes, on frozen lakes and rivers where permanent screens cannot be built, and on top of permanent screens that are buried in snow and so have become useless.

FIG. 5—PART OF THE SNOW-SCREEN SYSTEM

The portals of tunnels and snowsheds are liable to be blocked by drifting snow, so they have to be well screened, an example of which is shown in Fig. 7.

Snowsheds—At tunnel mouths, in cuts and in many instances on even ground and on embankments, snow screens do not afford sufficient protection to the track, so the line has to be covered over with snowsheds. At such places the ground formations as well as the presence of the sheds cause accumulation of great masses of snow, the depth of drifts often amounting to 3 or 4 m. over the ridge of the roof (i.e., 11 to 12 m. over rail top). In hillsides under steep rock walls, drifts exceeding 15 m. in depth have been found bearing on the shed roof. In winter when the snow is dry it carries itself to a great extent through internal arching. In spring time, however, the snow absorbs much moisture and in subsiding increases considerably in weight, forming an immense dead load which the sheds must be able to support. In sloping ground it also exerts a great side pressure.

With the exception of some built as masonry arches, all snowsheds are constructed of wood and consist of a close sheathing of 1¼-in. boards on a supporting system of round timber.

The forces that attack the snowshed are: (1) The snow pressure mentioned above, (2) climatic and biological forces, and (3) wind pressure.

In the lower portion of the western slope up to about 900 m. elevation, the climate is comparatively mild and moist and favorable to the common brown rot which is of biological nature and especially attacks the lower ends and unprotected tops of sticks.

In higher altitudes the air is very dry and, with a clear sky, the sun rays have a very great intensity and with wind and rain have a strong decomposing action upon the wood. The decomposition takes the character of a washing out or evaporation of the resinous components, leaving the cellular structure very brittle and tender. Telegraph poles that are cut at the base for exchanging, in falling snap short in several pieces. This decomposition is more pronounced in round timber when unprotected than in boards. Spruce especially stands up badly, so native pine of the best quality is used exclusively.

Wind pressure is not of great importance except during construction of sheds. Preliminary struts and scaffolding have to be very substantial on account of the sudden and violent storms. The lower ends of posts and permanent struts are bolted to rock or foundation stones as soon as erected, and permanent bolting of all timber is effected as soon as possible.

The above mentioned external forces dictate the choice of construction of the snowshed. All timber is enclosed to protect it against the climate. No eaves or other protruding parts are tolerated, as the subsiding snow will be suspended on them and break them off. As wounds in the wood form starting points for decomposition, lap joints and mortise and tenon joints are precluded.

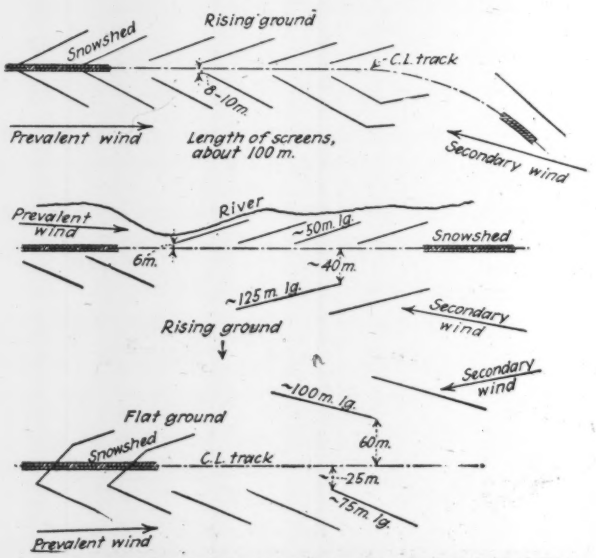


FIG. 6—TYPICAL ARRANGEMENTS OF SNOW SCREENS

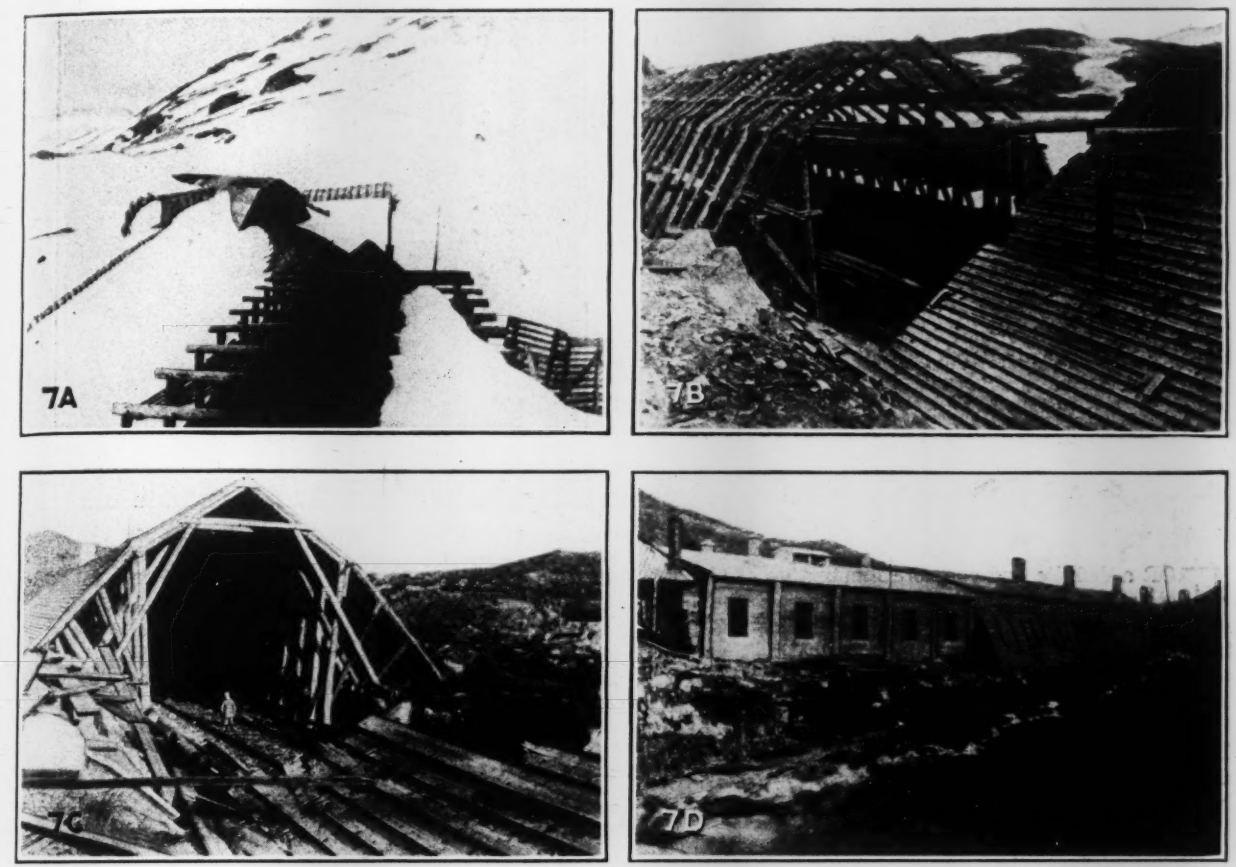


FIG. 7—(A) SNOW SCREENS AT A TUNNEL PORTAL, (B) SNOWSHED UNDER CONSTRUCTION, (C) SHED IN LOW CUT, (D) TURNTABLE (AT RIGHT) AND ENGINEHOUSE TRACKS UNDER COVER. ENGINEHOUSE PARTIALLY REBUILT IN CONCRETE

In Figs. 7 and 8 are shown some types of snowsheds. The distance between bents is from 1.0 to 1.5 m. The free profile inside the sheds has a height of 5.5 m. above railtop, the width being 5.0 m. on tangents. For posts and main struts, sticks of 7 to 8-in. top diameter are employed.

As the railway is steam driven, the smoke nuisance forms a great drawback in long snowsheds, to passengers as well as to the section men. To get rid of the smoke, long sheds are provided with wooden smoke ducts, 15 to 20 m. apart, on the roof ridge.

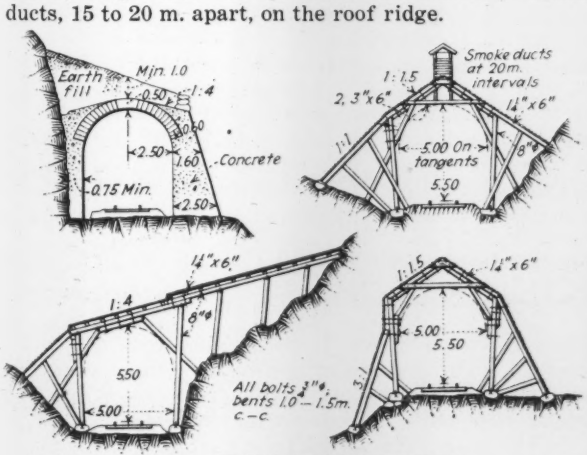


FIG. 8—TYPES OF SNOWSHEDS
Masonry arches are used where there is danger of avalanches.

To give the passengers a view of the grand mountain scenery as well as to give trackmen light and air for their work, one side of the sheds is, where possible, provided with trap doors which are opened in summer.

Originally most of the snowsheds were built of a much lighter construction, the distance between bents being 2 to 2.5 m., sheathing of 1-in. boards and timber of smaller dimensions. Extensive breakdowns under snow load have shown that the more substantial type of sheds is necessary.

On the mountain division there is a large number of tunnels aggregating about 17 km. in length, the longest being 5,300 meters. The aggregate length of snowsheds is about 30 km., so it is seen that of the 115 km. more than 40 per cent are tunnels or snowsheds. One wayside station is completely covered over, and at the depot stations Finse and Myrdal the turntable and the tracks to the coal sheds and engine houses are built in, as shown in Fig. 7.

With the active and passive protections mentioned above, the conscientious and efficient personnel have been able to keep this important traffic line between the two largest cities of Norway open all the year round. Avalanches may block the line for a day or two, and once in two or three years a train may have been stuck in the snow for some hours, but since the Bergen Ry. was opened in 1908, only one snow blockade of importance has occurred, that of 1913 when a hurricane resulted in a traffic stop that lasted for 10 days.

State Highway Developments of 1926 Awarded Blue Ribbon of Distinction by State Highway Engineers

THIRD ARTICLE

Topping and Widening the Boston Post Road

BY C. G. NICHOLS

Chief Clerk, Connecticut Highway Department, Hartford, Conn.

VIEW ON BOSTON POST ROAD

FOR a definite and concrete illustration of the outstanding road improvement policy of the State Highway Department of Connecticut, these details are given concerning road construction on a part of the Boston Post Road. The new road extends from Milford to West Haven 34,600 ft., or about 6½ miles. It is reinforced concrete 36 ft. wide, with 5-ft shoulders. The pavement only was put down in 1926, the grading having been done the year before. G. W. Blakeslee & Sons were the contractors.

The completion of this road leaves 12.8 miles to finish the program of widening the Boston Post Road to a 36-ft. pavement between the New York - Connecticut line and New Haven, a total distance of 50 miles. Of this 50 miles, 19 represent highways in city limits on which the state will not operate, leaving a net of 31 miles. Of this state road, 27 miles have been graded, and 19 miles have been surfaced with concrete or other pavement. During 1927, 4 miles will be graded and 12 miles will be paved, making a total when completed of 31 miles of 36-ft. highway.

New Structure on Old Road—From Milford-Orange town line the new construction was over a former penetration road, 18 ft. wide and from the Milford-Orange town line to West Haven it was over a former concrete road 18 ft. wide, 8½ in. thick in the center, and 6 in. thick on the edges. This old road was reinforced with medium-weight mesh. On this particular stretch, the new pavement is constructed in four strips 9 ft. wide and 9 in. thick, reinforced with three ½-in. rods around the perimeter of the slabs, and with 5-ft. long ½-in. bars in each corner to take care of corner breaks. From the Milford-Orange town line east for two miles, the new pavement has been laid on top of the old 18-ft. concrete pavement with a minimum thickness of 5 in. and a maximum thickness of 7 in., reinforced with a mesh reinforcement laid 2 in. from the surface and without any longitudinal center joint. There was a longitudinal crack approximately in the center of the old pavement in a good many of the slabs, and it is a question whether similar cracks will not appear in the new pavement. This two-mile section is experimental to find out whether this center crack will develop in the new pavement.

On each side of this 18-ft. pavement is constructed a 9-ft. strip 9 in. thick similar to the strips laid on the Milford end of the job. From the east end of the above pavement to West Haven, the new concrete is laid on top of the old pavement as much as possible, with a minimum thickness of 5 in. and a maximum thickness of 7 in., but is built full width with a center-line joint constructed at the time the concrete was poured. This center-line joint is a McGovern poured joint, and the paper part of the joint with a steel cap was installed in front of the mixer by having blocks a little higher than the joint, attached to the bottom of the mixer hopper over the joint material and by having the trucks back into the hopper with their wheels astride the joint.

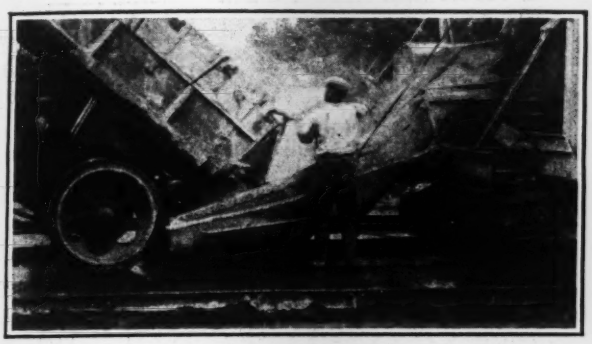
As the grade line varied from that of the old pavement due to unequal settlement of the old road, a crew of five men worked ahead of the mixer measur-

CONNECTICUT

Every valley shall be exalted and every mountain and hill shall be made low; and the crooked shall be made straight, and the rough places plain.—Isaiah, 40-4.

IT IS NOT contended that the highways of Connecticut were divinely foretold through the mouth of the Prophet Isaiah, but it is a fact that, during the last three years at least, the program of the Connecticut State Highway Department has been devoted in no small measure to constructing highways along the lines described by Isaiah. It is necessary only to travel throughout the state to determine to what extent this work has been accomplished. Sight lines have been improved, hills have been eliminated, valleys have been filled, highways have been broadened, so that valleys indeed have been exalted, mountains and hills have been made low, the crooked has been made straight, and the rough places made plain. This work has made travel much safer, more convenient, and has resulted in the speeding up of traffic without increasing the element of danger.—JOHN A. MACDONALD, *Commissioner.*

ing with a templet both for the transverse and the longitudinal joints, sawing the paper joint to an exact fit on the old pavement and to the exact top of the



SKIDS ON CHARGING SKIP CLEAR CENTER JOINT SET IN ADVANCE

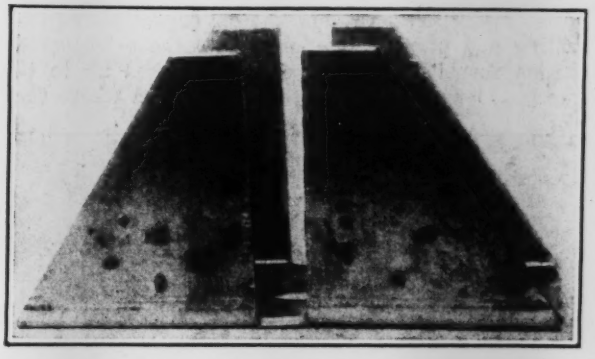
surface of the new pavement. This was accomplished with a band saw mounted on skids and run by a little gasoline motor. This could be attached behind a batch truck and moved ahead very quickly as the joint was installed.

The transverse joints in the new pavement were

CROSS JOINT MOLDS HELD UPRIGHT BY LITTLE PILES OF CONCRETE

installed over alternate transverse joints in the old pavement. This made joints 50 ft. apart in the new pavement as the joints in the old pavement were 25 ft. apart. The paper for the transverse joints was held in place by dumping concrete on each side, the mix being so stiff that no trouble was encountered in holding the paper in place. The longitudinal joints were held in place by sheet-metal brackets stamped out of ⅛-in. stock. These brackets were lined up by the crew of five men and held in position by hot pitch.

On a wet day a small amount of gasoline was slopped on the spot where the bracket was to go. This was lighted and resulted in drying the pavement so that the pitch would adhere. The paper that had been cut to fit the exact surface of the new pavement was then placed in the bracket with a steel cap over the paper. The paper joint was then oiled. Concrete was placed on both



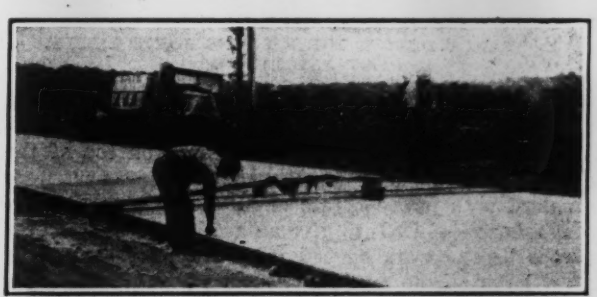
SHEET STEEL CHAIR HOLDS PAPER CENTER JOINT MOLD UPRIGHT IN LINE

sides of the joint, the reinforcement was placed and covered with concrete, and the slab was struck off with a finishing machine. The concrete was then allowed to get to almost its initial set; the steel caps were removed from the paper joint with special tongs; concrete was allowed to get its final set, and the paper

SETTING STEEL CAP ON PAPER JOINT AND OILING BOTH

joint was removed. The slab was covered with wet hay for eight days' curing; the hay was removed after fifteen days and the joint was poured with Headley good roads special joint filler. The pavement was opened to traffic after 21 days.

LINING IN CHAIRS AND SEALING THEM TO BASE WITH PITCH



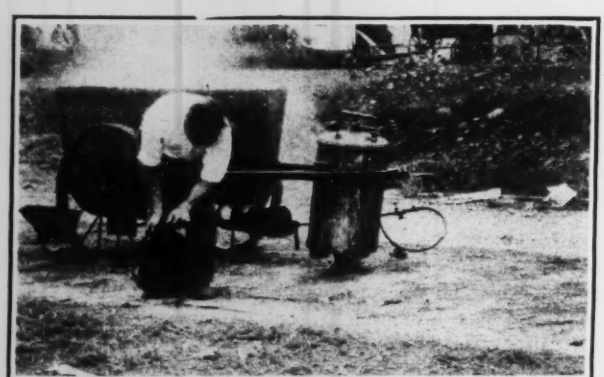
BROOMING AND EDGING THE SURFACED CONCRETE SLAB

During the time the 18-ft. strip was being poured and cured, traffic was handled on the two outside strips of subgrade. After the center 18-ft. strip was cured, traffic was turned on to it and the two outside strips were built. Where, due to changes in alignment, the new pavement did not come directly over the old pavement, it was necessary to set forms and fasten them to line and grade on top of the old concrete. To save drilling and pinning the forms into the old concrete, wooden forms 4x5 in. were used, blocked up to the true grade with earth tamped under them where they

SPREADING WET STRAW ON BURLAP COVERING TO CURE SLAB

did not exactly meet the old concrete pavement. In no case was it found necessary to block up over ½ in. For alignment, shores to pins driven into the shoulder beyond the concrete pavement were used as shown by the accompanying sketch.

Where banked curves were desired in the new pavement where the old concrete had no bank, a 6-in. form was buried 1 in. on the inside of the curve which left a 5-in. thickness of concrete at this point. On the high side of the curve, a 9-in. form with a 2-in. wooden



PORTABLE DEVICE FOR KEEPING JOINT FILLER HOT AND LIQUID

strip attached to its bottom was used, giving a 6-in. bank in an 18-ft. pavement.

Before any new concrete was poured on top of the old road, all old corner breaks in the old pavement were repaired with new concrete under traffic with a 2-per-cent mixture of CAL to give an accelerated set. These corner breaks were opened to traffic after four days, after having been cured by keeping moist three days. There were no corner breaks that failed after this treatment with the exception of one or two that were adjacent to telephone duct line manholes where the impact from trucks caused several failures. Carey Elastite ½-in. joints were used between concrete strips

CLEANING OFF CURING STRAW AND LOADING IT FOR FURTHER USE

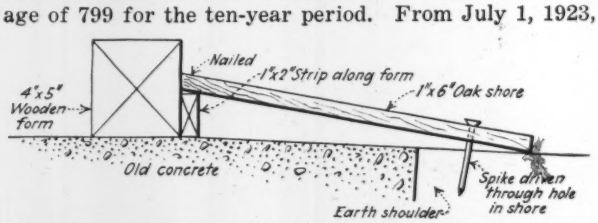
except where the concrete was laid over the old pavement.

Growth of Reconstruction—The fiscal year ending June 30, 1926, was the banner year in Connecticut highway reconstruction, as a total of 200 miles of highway was constructed and reconstructed. It is interesting to note that although the present net mile-

POURING JOINT FILLER WITH SNOUTED COAL HODS

age of state highways is 1952, yet during the 31 years of the activity of the department, a total of 2,700 miles actually have been built. It will be further interesting to note that of these 2,700 miles 747 miles or 38 per cent represent reconstruction.

From July 1, 1895, to Feb. 26, 1913, the state had operated on 1,043 miles, of which 62 were reconstruction. The period from Feb. 26, 1913, to June 30, 1923, showed a very large increase in the reconstruction work. During that period the state operated on 1,210 miles, of which 412 were reconstruction, an actual net mileage of 799 for the ten-year period. From July 1, 1923,



BRACING SIDE FORMS ON OLD CONCRETE PAVEMENT

to June 30, 1925, a period of two years, of a total mileage of 245.28, 151.25 was reconstruction, leaving a net mileage for the period of 94.03.

Short-Span Railway Rolling-Lift Bascule Bridge

Atlantic Coast Line R.R. Builds Double-Track Drawbridge Over a Small Navigable Stream—Machinery and Locks

RAILWAY development in the southeastern states often involves the crossing of several small streams which are classed as navigable and which, therefore, must be spanned by drawbridges meeting the requirements of the War Department. An example of a number of recent such structures of the Scherzer rolling-lift bascule type is the double-track bridge now being built over the Ashley River for the Atlantic Coast Line R.R., near Drayton Hall, S. C., which has a span of 76 ft. c. to c. of piers, giving a clear channel width of 60 ft. General plans of this bridge are shown in Fig. 1. Other similar but smaller bridges have spans of 40 and 56 ft.

As the Ashley River bridge was built in connection with the double-tracking of the railroad, and replaces an old single-track swing span, it was possible to utilize the old piers as part of the substructure. Thus the old pivot pier supports one corner of the approach or track span, while one of the old end piers is enlarged to serve as a support for one corner of the bascule span. All these piers are steel cylinders filled with concrete which rests on wood piles.

It will be noted that the segmental girders on which the span rolls are not extensions of the main girders, but are above the level of the latter, to which they are attached by heavy connection plates and by a framing of built-up members which also support the counterweight. This counterweight is framed between the main trusses and is beyond the ends of the track girders when the span is open. The bridge is a through-girder structure, with two spans; the bascule span of 76 ft. and the 25-ft. fixed or track-girder span upon which the segmental girders travel. Fig. 3 shows the track girder and rack.

For the bascule span there are two through girders 9 ft. 6½ in. deep over the flange angles, which are 8x8x$\frac{7}{8}$ in. The web plates are ½ in. thick and each chord has flange plates 18x$\frac{3}{8}$ in. Floorbeams are framed between the girders, with stringers between the floor beams, this floor system bringing the base of rail 3 ft. 9½ in. below the top flanges of the main girders.

In the segmental heel girders the webs are $\frac{3}{8}$ in. thick, with side reinforcing plates in addition to the flange angles, but with no cover plates on the polygonal faces. Instead of shaping the structural steel flange in a curve, as in the earlier Scherzer bridges, the flange angles form a polygonal outline. This change in form was adopted to simplify manufacture and reduce shop costs. To the flat faces are bolted or riveted steel castings, having a radius of 17 ft. 3 in. on the rolling face, which has a length of about 25 ft. In this face are fifteen

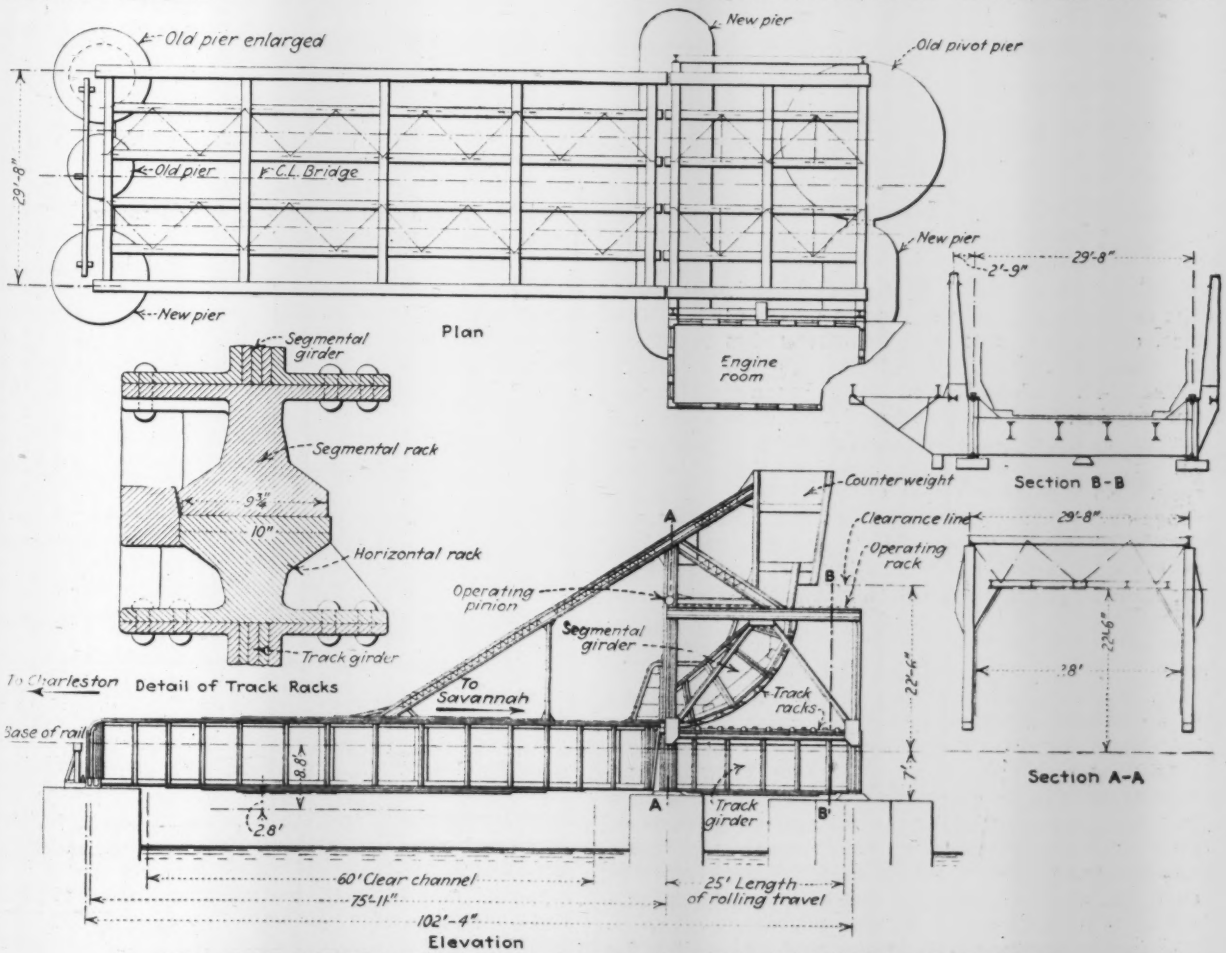


FIG. 1—ROLLING-LIFT DRAWBRIDGE FOR 60-FT. CHANNEL—ATLANTIC COAST LINE RY.

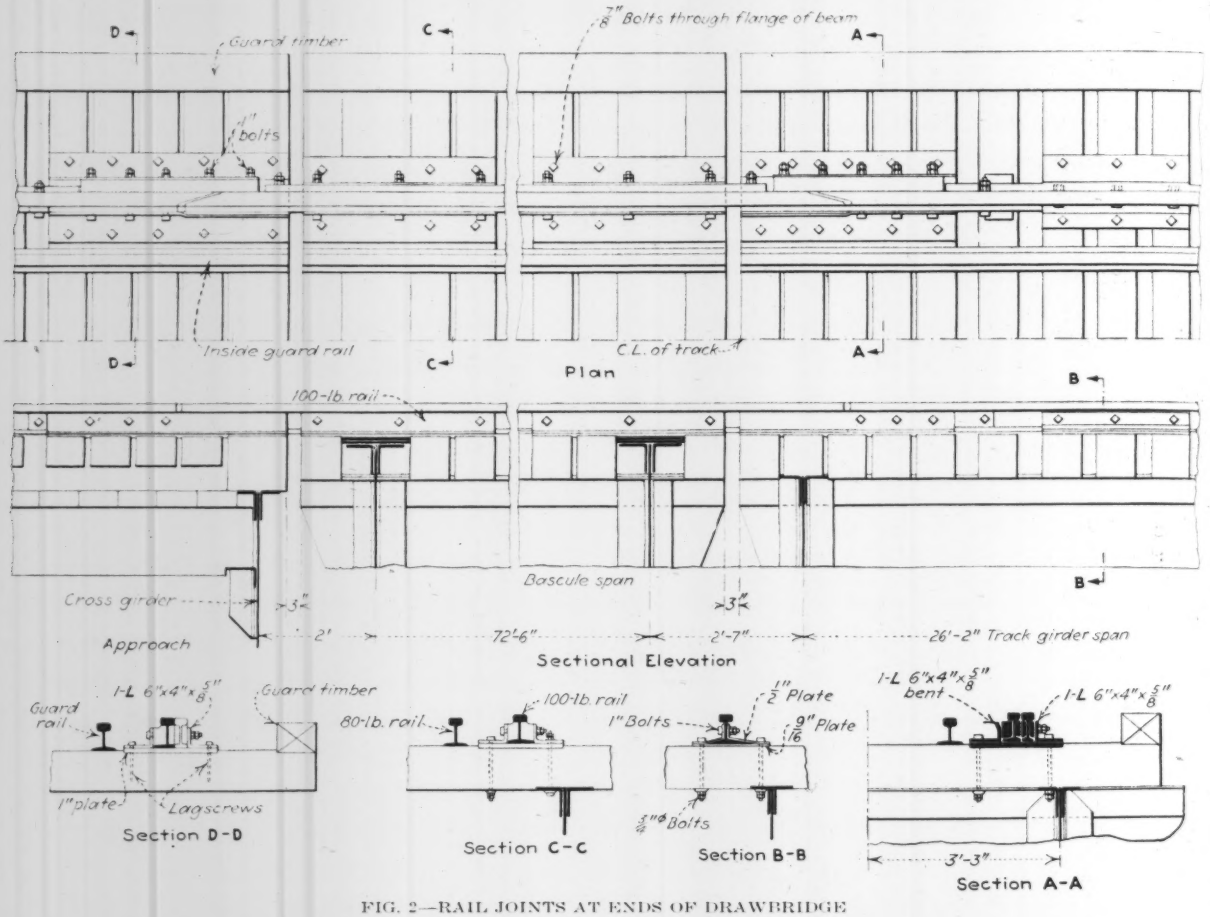


FIG. 2—RAIL JOINTS AT ENDS OF DRAWBRIDGE

recesses 18¾ in. c. to c., to engage the lugs or teeth of the track castings on the track girders. From the closed to open position the span moves through an angle of about 83 deg. and rolls back about 25 ft. horizontally. The total weight of the moving structure is about 526 tons, of which the concrete counterweights represent 311 tons.

The 25-ft. track girders of the fixed span are of heavy construction, 8 ft. deep, as they have to carry the full load of the draw span in its open position. Floorbeams and stringers are framed between them, as in the bascule span. No top cover plates are used, but to the top flange angles are bolted steel castings forming a track for the segmental girder. Teeth or lugs form guides engaging the recesses in the rolling heel, and thus hold the span in position against longitudinal movement or creeping.

Operation of the bridge is effected by a single 50-hp. gasoline engine in a cabin on the approach span. A train of shafts and bevel gears from this engine ends in an overhead spur gear at the center line of the bridge, driving a transverse shaft with a train of spur gearing at each end. Each of the two trains of spur gearing ends in an operating pinion which rides on a horizontal rack carried by a structural steel frame or tower, so that as the pinions are driven they move the bascule span backward or forward. Power from the engine is applied through a transmission system consisting of a rotating and sliding shaft with bevel gears. The engine has an electric motor and foot switch for starting. Chain sheaves provide for operation by hand by two men in 30 minutes.

The end lock, Fig. 4, is a horizontal bar 7x1½ in. lying in the center line of the bridge at the free end of the lift span, and having a sliding fit in a slot in the end floorbeam and in a guide bolted to the top of the rest pier. This lock is operated from a lever in

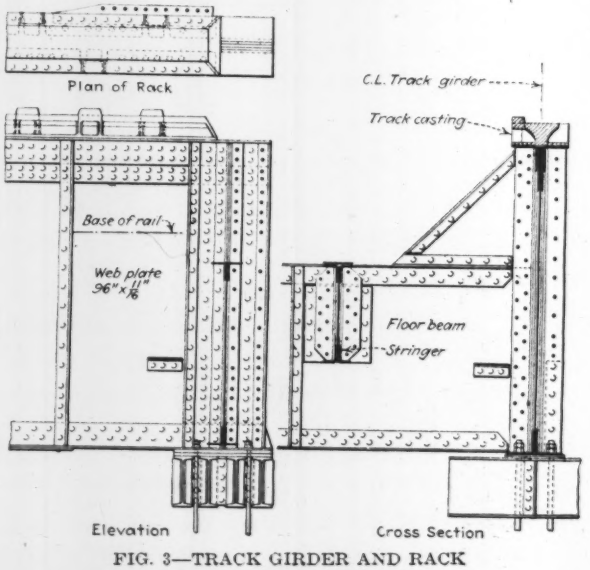


FIG. 3—TRACK GIRDER AND RACK

the cabin, but can be operated only when the span is lowered so that the lock rods on the fixed and movable spans are engaged by floating levers, as shown. A latch prevents the lock being thrown to the closed position while the bridge is open. It will be noted that a vertical bar with adjustable sleeve and lock nut rests on the pier. When the bridge is raised, this bar drops and engages a notch in the lock bar, but is raised and released again when the bridge has been closed and seated.

A pneumatic buffer mounted on the end floorbeam

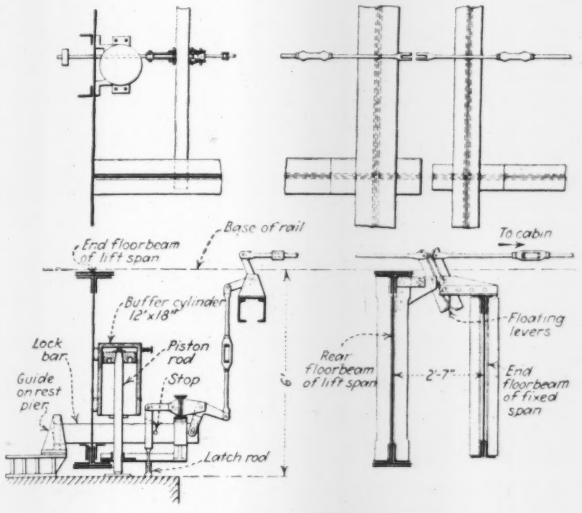


FIG. 4—END LOCK AND BUFFER

consists of a vertical cylinder which is open at the bottom, as shown in Fig. 4. With the bridge raised, the piston falls to the bottom of the cylinder, where it is held by a stop plate. As the bridge closes, the piston rod, projecting below the girder, strikes a bearing plate on the rest pier; with further movement of the descending span the piston is forced up in the cylinder, compressing the contained air, which escapes through a check valve. An adjustable needle valve provides for admission of air above the piston when the bridge is raised again.

Beveled joints formed in the 100-lb. track rails are provided at the break of floor at each end of the bascule span, as shown in Fig. 4, all the bridge rails rising above the fixed rails as the span opens. An outside guide rail, bolted only to the fixed rail, lies against the track rails and serves to carry worn wheel treads across the joint.

This bridge was designed by the Scherzer Rolling Lift Bridge Co., Chicago, the design being for Cooper's E-60 loading and based on the specifications of the American Railway Engineering Association for fixed railway bridges and for movable bridges. The steel was fabricated and machinery supplied by the Fort Pitt Bridge Works, Pittsburgh, Pa. The construction of the bridge was under the direction of J. E. Willoughby, chief engineer, Atlantic Coast Line R.R. Foundation work was done by J. A. Kries, contractor, under the direction of D. B. Packard, engineer of construction. Steel erection and installation of machinery was done by railway forces under the direction of G. G. Thomas, bridge engineer. This bridge was put in operation late in 1926.

Heavy Autumn Rainfall in Illinois in 1926

THE severe rains and widespread flood conditions throughout central Illinois during the autumn of 1926 were reviewed by Clarence J. Root, meteorologist of the U. S. Weather Bureau, Springfield, Ill., at the recent annual meeting of the Illinois Society of Engineers, abstracted below with comments on storm frequency and runoff, by another writer:

During June and July, 1926, rather heavy rainfall occurred at some stations in central Illinois, but at others nearly droughty conditions obtained. The August precipitation was generally above the normal. Some heavy totals were: Decatur, 7.47 in.; Grafton, 7.55; Hoopeston, 8.81; Palestine, 9.24; Peoria, 6.79 inches. These rains caused no damage. The real trouble started in September, which was the rainiest month in the climatological history of Illinois. Floods resulting from the excessive rains covered large areas. A period of rainfall set in Sept. 1 and continued almost without interruption for five days, during which time many stations recorded from 4 to nearly 8 in., and at several places there were 24-hr. falls ranging from 3 to more than 5 in. In a number of places the normal for the entire month of September had already been exceeded in the first five days, and at three places it had been more than doubled. This protracted rainy period was due to low barometric pressure that, instead of moving on in the normal manner, persisted west of the Mississippi River.

This condition was followed by the excessive rainfall of Sept. 8. At 7 a.m. a trough-shaped cyclone, commonly known as a "low," extended over western Iowa. By 7 p.m. this trough reached southward across northwestern Illinois and by the following morning the disturbance had passed on to Ontario. The heavy rains occurred during the afternoon and evening of the 8th, covering a belt across the center of the state, with total as follows: Lincoln, 3.39 in. in 24 hr.; Rushville, 3.51 in. in 24 hr.; Springfield, 5.51 in 15 hr.; Tuscola, 5.07 in 15 hr.; Griggsville, 6.06 in 13 hr. 15 min.; Alexander, 7.02; Charleston, 8. At Springfield, 3.01 in. fell in 2 hr., a record for the station, and the amount from Sept. 3 to 8, inclusive, 10.83 in., was never before equalled in six days, and only twice in entire months.

For the 20 days from Sept. 12 to 30, inclusive, there was an average of 11 days with measurable precipitation in the central part of the state. The first five days of October, like the first five of September, were decidedly rainy. No station escaped more than one day and only a few even that one. The totals for the five-day period ranged from 1.11 in. to 6.34 in., with 57 per cent of the stations having more than 3 in. and four of them in excess of 5 in. The average precipitation for central Illinois for September was 12.07 in., or 8.42 in. above the normal. From Sept. 1 to Oct. 5, the totals range from 8.71 to 21.67 in. Those of more than 15 in. are as follows: Alexander, 20.98; Bloomington, 17.55; Carlinville, 15.32; Charleston, 17.18; Clinton, 21.61; Decatur, 21.67; Griggsville, 21.28; Hoopeston, 16.01; Lincoln, 15.70; Pana, 15.05; Pearl, 21.57; Roberts, 15.79; Springfield, 19.24; Tuscola, 16.59; Warsaw, 15.07; White Hall, 19.42; and Windsor, 17.29 in. The normal annual precipitation for central Illinois is 36.02 in.

Storm Frequency and Runoff—The rainfall records, given above, were supplemented by data in a paper from the office of Pearse, Greeley & Hansen, Chicago. A brief abstract is given below:

From this study it appears that a characteristic feature of this period of heavy rain was the duration. Thus, at Alexander the maximum consecutive six days of rainfall amounted to 9.53 in., with an indicated occurrence of once in 100 years. The storms of three to five days duration appear to have an occurrence of once in 50 years, but the one-day maximum storm may occur every 15 years.

Records of runoff for twelve gaging stations show the maximum runoff occurred on the Sangamon River at Monticello on Oct. 4, being 24.55 sec.-ft. per square mile. A comparison of the five-day rainfall and ten-day runoff, thus allowing some time for the discharge of accumulated rainfall, indicates that for the Mackinaw River the discharge was 6.68 in. and the rainfall 15 in., while on the Sangamon River the respective figures were 7 in. and 20 in.

New York to Build Four Miles of Shield Tunnel Under Difficult Conditions

$25,000,000 Brooklyn Rapid-Transit Link to Pass Through Narrow Streets, Below Four Subways and Under River—Void-Filling Method Adopted to Prevent Settlement—Special Problems at Stations

A CONSTRUCTION problem of extraordinary magnitude and difficulty is about to be undertaken by New York City for the Brooklyn extension of the city's new rapid transit system. In point of cost it will be one of the largest municipal contracts ever let, totaling about $25,000,000, though it may be let in two sections instead of in one. Many complicating features are involved in the work, making it a formidable task for engineers and constructors. Four years' time is allowed for completion. It is expected that bids will be called for within a week or two.

A two-tube tunnel, 9,104 ft. long, is to be driven under the East River and a distance of about half a mile each into Manhattan and Brooklyn. The line passes through narrow streets, of which Fulton St. is only 50 to 53 ft. wide between building lines, and the outer sides of the tubes will be within a few feet of the house line. The bottom of the tubes will be at a depth of from 50 to 80 ft. below the ground surface and from 20 to 40 ft. below groundwater level. The soil is fine sand, a material which calls for the tunnel builder's best skill and watchfulness. In view of the location, in a closely built-up business section, avoidance of all settlement is obviously a prime necessity, and as underpinning all buildings along the line would add very greatly to the cost, a special void-filling method has been adopted as a safeguard. The tunnel passes under four subways (three present and one future), two of which will be in direct contact with the new structure. In addition, two stations must be built over and between the tubes, in large part below groundwater level; one of them is to be constructed by open-cut excavation to depths as great as 50 ft., and the other by mining.

General Features—The Fulton St. line forms the southern continuation of the Manhattan part of the city's new Eighth Ave. subway line, of which a general description was published in *Engineering News-Record* June 17, 1926, p. 970. Construction is already well advanced on the entire length of line from the north end of Manhattan Island south to Bank St., and recently contracts were let for the three sections from Bank St. south to Park Place. The Fulton St. link connects with the south end of this work at Park Place.

It extends southward in Church St. for three blocks to Fulton St., turns east between Vesey and Fulton Sts. under the vestry building of St. Paul's Church, extends through Fulton St. to the East River, across the river to Cranberry St. in Brooklyn, and under Cranberry and High Sts. to Jay St. For its entire length the structure is partly or wholly below groundwater levels, which in view of the nature of the soil was the reason for resorting to shield tunnel construction.

By reference to Fig. 1, a map and profile, these general conditions will be evident. The complicating feature of the existing subway crossings, shown by a separate diagrammatic plan in Fig. 1, controlled various details of the profile. In general, the maximum gradient is 3½ per cent, but in Church St. it was necessary to go to 4.1 per cent because of the subway crossings over at Park Place and under at St. Paul's churchyard, which imposed such severe limitations that even the 4.1 per cent grade required special construction to get through under the Broadway-Church St. pair of tunnels. The situation in Church St. is further complicated by the fact that the four-track line coming south to this point divides at Park Place, the easterly two tracks continuing on southward to a stub terminal while the westerly two tracks go to Brooklyn via Fulton St. and therefore must pass under the two stub tracks.

East of Church St. the Fulton St. line crosses successively under the existing two-track subway in Broadway (the first subway line built in New York, and now part of the Interborough east-side or Lexington Ave. line), the future Nassau St. subway (projected for a dozen years and destined to form a part of the Brooklyn-Manhattan Transit subway network), and the William St. subway (a part of the Interborough west-side or Seventh Ave. line). These three crossings have sufficient clearance to impose no limitations on the tunnel construction, as the Nassau St. crossing is to be built under this contract.

Selection of Fulton St.—As indicated in our article on the new system (June 17, 1926), Fulton St. and Wall St. were originally selected as alternative locations for the Brooklyn connection of the Eighth Ave. system, these streets being the most desirable considering geographical conditions for both Manhattan and Brooklyn. It was desired to carry the line either through the financial district or as close to it as possible, in view of the large traffic originating and terminating there. If built in Wall St., the construction under that street would have been in deep rock tunnel perhaps 100 ft. below the surface. Owing to the difficulty of constructing the deep approach required under Church St. to such a tunnel and the rock section under the existing subway in Church St., together with the difficulty of securing the validation of the Wall St. route by consent of the property owners without resorting to the Appellate Division of the State Supreme Court, and in view of the alternative availability of Fulton St., the latter street was selected.

General Arrangement.—It was necessary to build a station in Fulton St. to accommodate the traffic. On account of the depth of the structure below water level and the narrow width of the street, it was considered best to construct the trackways by tunneling and build the station platform between the tubes and the station structure above the tubes, by open cut, as sketched by sections in Fig. 2.

The tunnels are placed 26 ft. to 32 ft. 10 in. apart (28 ft. in the river, 26 ft. generally in Fulton St. and about 32 ft. at stations). This permits a station platform about 22 ft. wide. As the platform must serve traffic in both directions, great care was taken to mini-

mize the encroachment on available platform width by use of a series of narrow stairways.

In the design of the tunnels themselves, practice as developed in previous tunnel work in the New York subway line furnished a thoroughly satisfactory precedent, which was followed with only slight variations.

In the last river tunnel subway contracts, 18 ft. outside diameter with 9-in. flanges was the standard for the cast-iron tunnel sections. In the new contract the diameter is increased to 18 ft. 3 in. over all, which practice has shown to be desirable from an operating standpoint. The flange remains 9 in. deep. The rings were lengthened from 26 in. to 30 in., tunnel-driving experience having shown the greater length to be readily manageable and advantageous because of the econ-

ing of the flanges by the corner tapers and the use of high-strength bolts are expected to give a slightly greater margin of strength to reduce the difficulties occasionally arising under especially severe construction conditions.

The lining will be of cast iron except for a few rings of cast steel just east of Broadway, where heavy superstructure concentrations may bring unforeseen strains to bear on the tunnel shell. The metal shell is to be lined with concrete to a thickness of 15 in. from outside of shell.

Void-Filling System—The two tunnels are so close to the vertical planes of the building fronts on either side of the street as to create risk of settlement in case of loss of ground in the tunnel construction. Work at

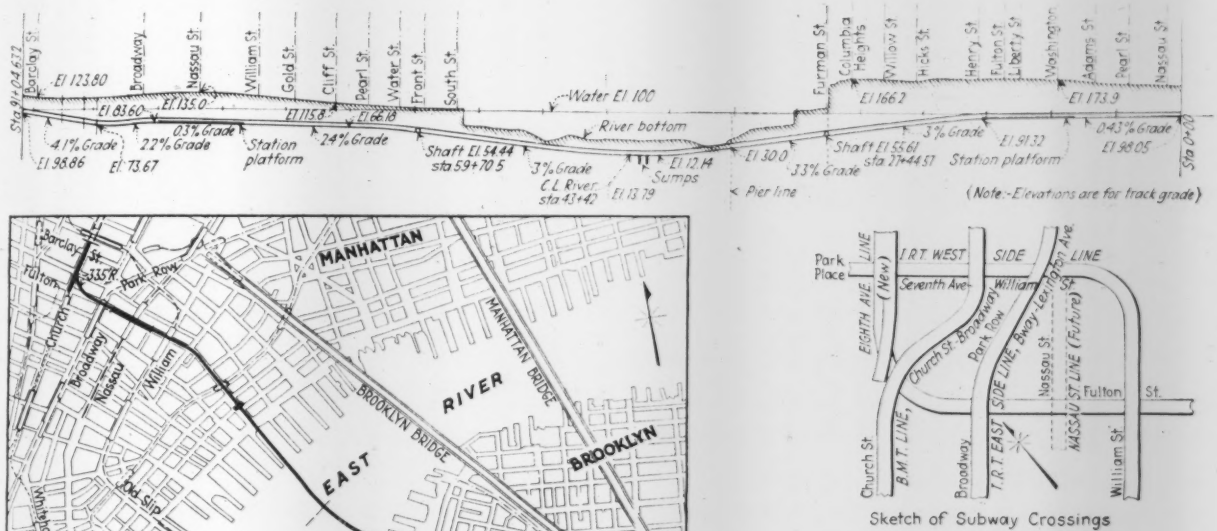


FIG. 1—LOCATION AND PROFILE OF FULTON ST.-CRANBERRY ST. SUBWAY

omy in bolts and joints. The ring consists of nine segments and key, as previously used, with 1⅜-in. shell and 2-in. flange thickness, but the tapered thickening of the shell toward the flanges, used in previous tunnels, was in this case supplemented by a similar tapered thickening of the flanges toward their corners, which it is believed will strengthen the segments and reduce the chance of cracking under exceptional construction strain. Also, high-tensile-strength bolts will be used in place of the mild steel bolts used in the previous rapid-transit tunnels (high-tensile bolts have been used in the 30-ft. Holland tunnel under the Hudson River, just completed). Previous practice is followed in using cored bolt holes, machined joint faces, and unfinished boss faces. Watertightness is to be assured by placing grommets under head and nut, while the joints are to be made tight by lead strip calking along their inner edges, as first used in the Pennsylvania R.R. East River tunnels 20 years ago.

Experience with the present tunnels has shown these features of lining construction to assure adequate strength and permanent tightness, and the strengthen-

the tunnel face must be controlled by most careful working to prevent any loss of ground, but the 2- to 3-in. void around the lining in the wake of the shield must be dealt with separately.

In the construction of the Old-Slip-Clark St. and Whitehall-Montague St. tunnels of the second rapid-transit system, built 1914-1917, the contractor, Flinn-O'Rourke Co., made successful use of a method suggested and later patented by John F. O'Rourke, namely, blowing small-grained gravel under high air pressure into this void while the shield was being shoved. It was found that by the proper use of this method settlements overhead were greatly reduced. The New York Board of Transportation is negotiating for the patent right to use this system for present work. The specifications for the work will in any case require the contractor to fill the void behind the tail of the shield in the land tunnels by some method approved by the engineer, and the present outlook is that the gravel-shooting method will be used. Grouting with cement to refusal will be required in addition. In the river section some approved method of void filling will be used but the problem here is pri-

marily that of prevention of tube distortion and settlement; ground settlement is of little if any moment.

The under-river problem is not materially different from that presented by the earlier rapid transit tunnels, except that the depth of water is somewhat greater at the present crossing and the cover therefore thinner. The maximum depth, at lowest point of the tunnel, is 91 ft. from mean high water to bottom of iron. The soil is sand, except for a short length of silt. Temporary clay blanketing will be depended upon to counteract the unbalanced air pressure during the process of tunneling. In part of the river width there will also be a permanent clay blanket banked with riprap, to serve as a permanent protection to the tunnel structure.

Four Subway Crossings—Immediately beyond the north end of the new section the subway passes over the deep-lying structure of the Seventh Ave.-William St. subway line in Park Place, and 2½ blocks south it passes under the Broadway-Church St. subway, both crossings being made with minimum clearance. At the latter crossing the new structure will be entirely below groundwater level, and accordingly it was necessary to continue the compressed-air shield work westward to this point. However, the westerly tube of the Broadway-Church St. line could not be cleared by the shield tunnel section of the new line without unduly increasing the grades between this point and Park Place. Accordingly, the construction is unusually complex. The shield work is continued west under the easterly tube of the Broadway-Church St. line, but is stopped before reaching the west tube; the remainder of the undercrossing is built from the north end as a rectangular concrete box section with thin roof of heavy transverse steel girders embedded in concrete, constructed by drift tunneling or mining methods under compressed air.

One block to the east, the line crosses under the Lexington Ave. or Interborough east-side subway line, which here runs south under Broadway. The old structure is close to the street surface, and the new tubes therefore have ample clearance below it. However, a passageway forming part of the mezzanine deck of the new Fulton St. station east of this point is carried under the old subway, to provide an entrance on the west side of Broadway; this passage, which will have to be constructed by timbered drifting, will make close contact with the floor of the old subway.

In the two north-south streets next east of Broadway, Nassau St. and William St., subway crossings are also provided for. At William St. there is ample clearance. At Nassau St., where there is no subway at present, a double-deck line is to be built in future, and the depth of this future structure required resorting to special construction in order to obtain the thinnest possible floor between the lower level of Nassau St. tracks and the ceiling of the track spaces in the Fulton St. structure. This floor, as shown by one of the sketches in Fig. 2, is to be of trough type, consisting of alternate horizontal and vertical channels, to receive the ties of the future Nassau St. lower deck. The builder of the present Fulton St. line will be required to construct also the overlying Nassau St. double-deck structure within the width of Fulton St.

A station is to occupy the two-block length from Broadway to William St. It will be a structure of remarkable character. Typical cross-sections are shown in Fig. 2. The station will contain two floors above the track-platform level, a lower and an upper mezzanine, of which the latter is to constitute a free passageway between Broadway, Nassau and William Sts., turnstiles or ticket control being located only along one side. Communication between lower and upper decks is to be made by inclines or ramps in order to eliminate stairs as far as possible. A sufficient number of inclines between decks, in conjunction with upper and lower stairway flights, is provided so that after the Nassau St. subway is completed and operating (when the Broadway-William St. station will be virtually cut in two by the Nassau St. structure) the east and west halves of the station will be self-contained operating units.

The station has a depth of about 50 ft. The plan of construction involves driving the tunnels first, and after their passage excavating a sheeted and braced trench of the width of the station superstructure—which is practically the curb-to-curb roadway width of the street—down to the top of the tunnels and between them to a foundation level just below the finished station platform level. Distributing girders are to be placed here to support columns and cross-girders on which the station superstructure will rest. This work must be done in the open, although extending to a depth of 15 to 20 ft. below groundwater level. The design, it will be seen, is such as to permit the excavation to be done under most favorable circumstances, the deep excavation being in the space between the already constructed cast-iron tunnel tubes. It will be understood, of course, that in the course of the station construction the inner side plates of the tunnel rings over the station platforms will be removed.

A quite different solution of a somewhat similar problem was arrived at in the case of the Brooklyn station, located at the crossing of Cranberry St. with Brooklyn Bridge Plaza. The traffic capacity needed here is considered less than that at the Broadway-William St. station, and a simple intertrack platform supplemented by a mezzanine, extending about half the length of the station, leading to escalators, was believed sufficient. Both levels are to be constructed by timbered mining methods, a column and girder structure with concrete wall and roof being built in this excavation.

Sumps—A new form of construction is used to provide sumps at the two sags in this tunnel section, one of which occurs at the middle of the river and the other at the crossing under the Broadway-Church St. line. In the latter position a sump well sunk below tunnel level, between the two tubes, and a pump room above it will be built. The well is below water level, and will be constructed as a cast-iron segmental shell and will be sunk by caisson methods under air pressure. The pump chamber will also be built under air pressure but in a timbered drift. The under-river sump will comprise four wells, two in each tube, which are to be similar to the Church St. sump, namely segmental, cast-iron shells sunk as caissons and provided with a concrete floor.

Electrolysis—In order to provide a protection against electrolysis of the tunnel lining electric bonding is provided wherever the continuity of the iron is interrupted. This is the standard practice in cast-iron tunnel construction. Suction pipes will lead from the wells to drainage pumps mounted on the duct-bench along-

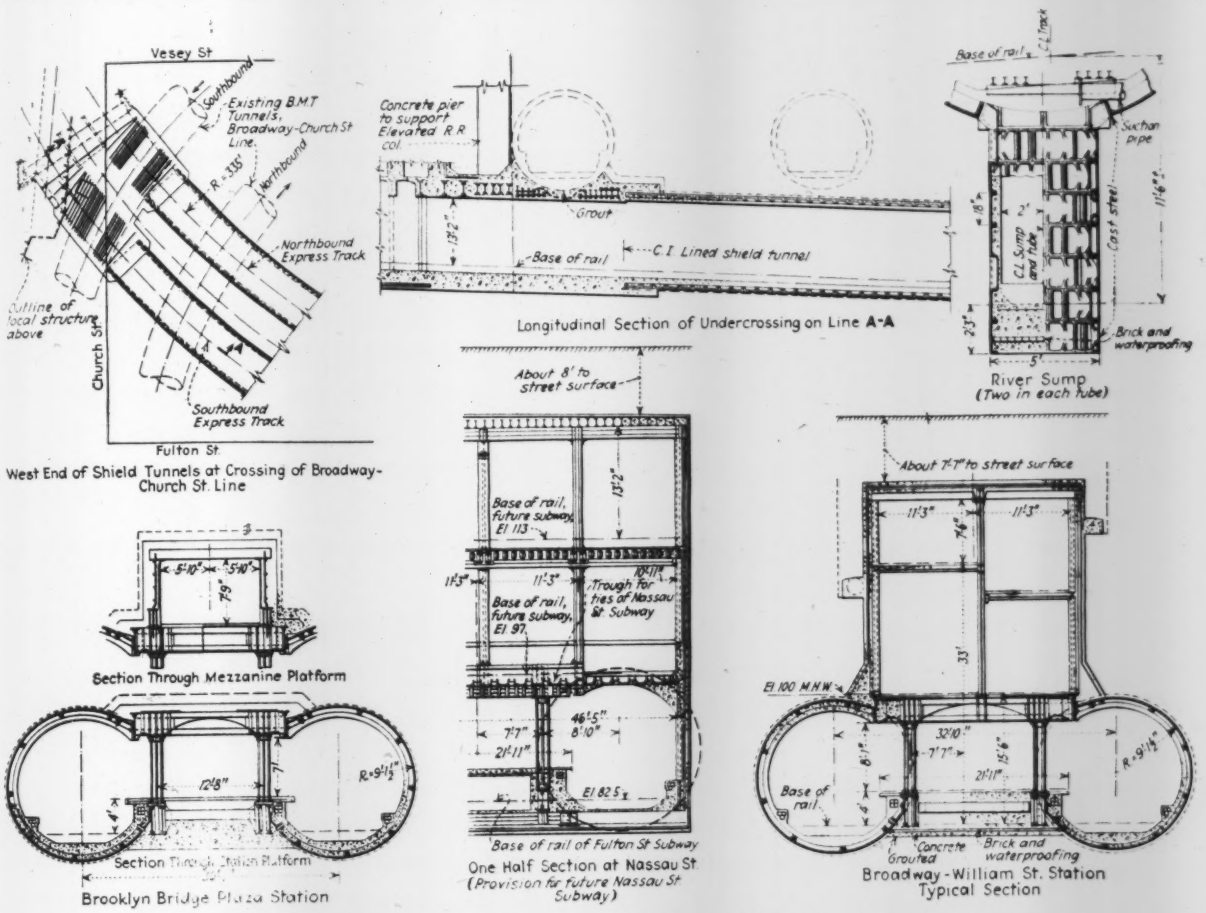


FIG. 2—CROSS-SECTIONS SHOWING MAIN FORMS OF CONSTRUCTION OF FULTON ST. TUNNEL

side the track. The under-river sump construction is sketched in Fig. 2.

Arrangement of Construction Work—It is proposed that the contractor shall carry out the entire shield tunnel work from two shafts, one on each river bank, 3,200 ft. apart, which means that he will have to do about ½ mile on the landward side and about 1,600 ft. on the river side of each shaft. The open-air work at the west end of the section will, of course, be constructed by direct attack at that point.

The work will be offered as one contract or two; alternative bids will be asked. If it is let in two contracts, the line of division between them at the middle of the river will be left indefinite to the extent of 75 ft. either way of the river center line. The contractor on each side will be required to stop his tunnel at a point within 75 ft. of the river center line as the engineer may require. This provision is expected to facilitate the matter of arranging for junction.

Four years construction time is to be allowed, with an additional six months for the restoration of the street surface.

It is interesting to record that during the planning of this work very careful consideration was given to the use of the trench method of construction in the East River, since no rock is expected to be encountered and it would therefore be possible to provide the necessary dredged trench with minimum difficulty. River towboat interests, however, opposed the use of this method so strongly that it was abandoned.

This work is being done under the direction of the Board of Transportation of New York City, John H. Delaney, chairman; Daniel L. Ryan, commissioner; Robert Ridgway, chief engineer. Col. J. R. Slattery is deputy chief engineer of construction and Sverre Dahm is deputy chief engineer of designs. The division engineer in charge of field operations is J. B. Snow and the division engineer in charge of design is A. I. Raisman. The designing engineer directly in charge is J. H. Quimby.

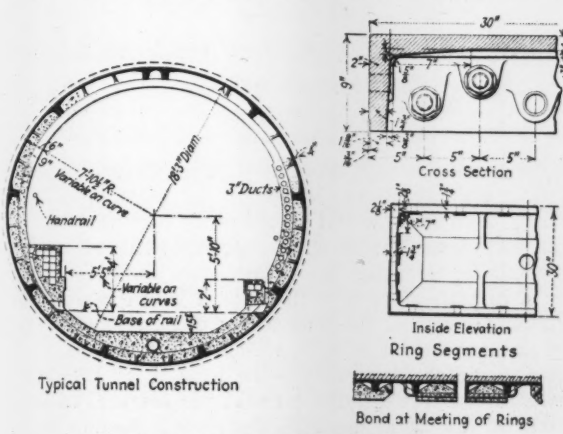


FIG. 3—TYPE OF IRON LINING

From Job and Office

Hints That Cut Cost and Time for the Contractor and Engineer

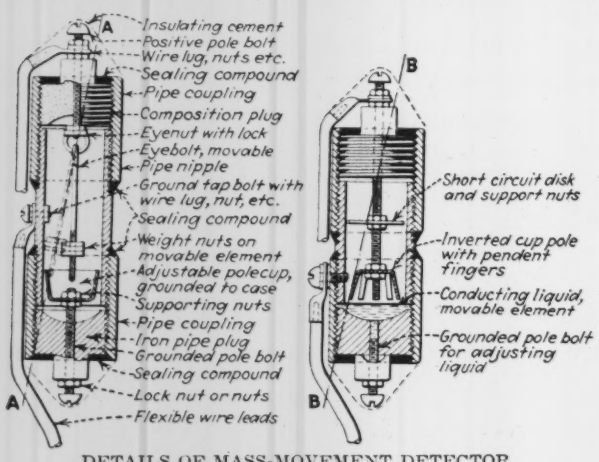
Mass-Movement Detector for Use in Dangerous Embankments

By Thomas M. Roberts
Associate Electrical Engineer, M. E. Division, Supervising Architect's Office, Washington, D. C.

IT HAPPENS occasionally that new railroad fills, or embankments exposed to floods, slide out or are washed out sufficiently to make the supported track unsafe without disturbing it enough to break the rail bond and thus give an indication of trouble on the signal system. As a method of giving such signal indications the device herein described may prove useful. It is called for convenience a mass-movement detector.

The accompanying figure shows two of several possible arrangements of the device. It is a mechanical switch which opens or closes an electrical circuit by the force of gravity when it is moved from a predetermined setting enough to make it break or make the circuit of which it is a part. With such a device it would be possible to detect even slight movements of any large mass such as a railroad embankment or the sides of an earth cut. By placing one or more of the detectors within the embankment or side of the cut and connecting it to the automatic signal system any movement of the mass sufficient to tip the detector from its vertical position would open the circuit and give a stop indication on the signal system, similar to that given by a broken rail. In case the detector was to be used on a railroad having no signal system it could be connected with very little expense to a signal light set up temporarily at a safe stopping distance from the embankment or cut whose stability was in question.

Such a method of indicating the movement of unstable masses would be particularly desirable in the case



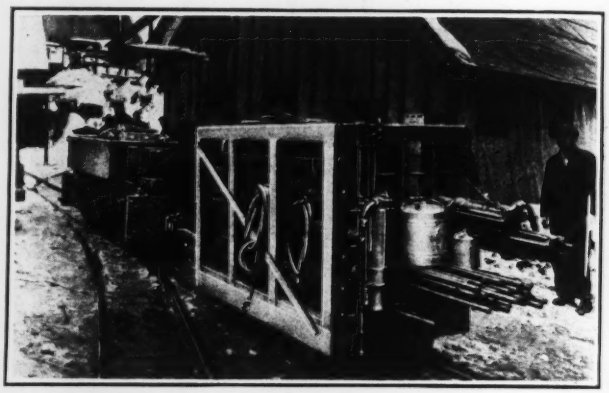
DETAILS OF MASS-MOVEMENT DETECTOR

of high, new fills on unstable ground, deep cuts through clay, or embankments saturated by floods in river valleys.

The method of constructing these detectors is simple and is clearly indicated in the accompanying figure. They can be made in large part from standard stock pieces of commercial hardware or those made up at small expense. The principle of operation is the same whether the movable member is a suspended rod as in the left-hand figure, or a conducting liquid like mercury, in the right-hand figure. By adjusting the operating arrangement any degree of sensitiveness can be obtained.

A Drill Steel Car Convenient for Crews at Tunnel Heading

IN driving the Cascade tunnel for the Great Northern Ry. in Washington a drill-steel car has been developed that very effectively serves the requirements of crews at the tunnel heading. It consists of a frame made of 4x4's with 1-in. round steel bars to serve as racks for



DRILL STEEL CAR READY FOR TUNNEL SERVICE

the drill steel. These bars and the upright posts of the car are so placed that there are four tiers each 5 racks high. There are also hooks on the ends on which drills can be hung and air hose connections, etc., are placed on top or slung from side bracing rods.

The frame is armored with strap iron and is firmly braced to withstand the rough usage attending service in the tunnel.

Taking Advantage of Weather Forecasts Aids Construction

By John M. Weed
Columbus, Ohio

FREE as we are now from most superstition, we are yet, to a great extent, dependent on the state of the weather. Fortunate would be the contractor who could lay out and plan his work with a certainty that so many days would be fair, that the temperature would not fall below a certain mark and that for a given period he would be free from the menace of floods. However, there is an agency available, which, if put to use, will materially aid the contractor—the local U. S. Weather Bureau. Here are statistics on heat and rainfall, winds, cold waves, just what has occurred in that locality ever since the office was established; here are facilities for

keeping tab on temperature and air pressure variations.

The U. S. Weather Bureau is able to make reliable forecasts 24 to 36 hours in advance, and to furnish material for intelligent guesses several days ahead. Contractors who know how to use the services of the weather man have found him one of their valuable resources, and, since making the most of available resources is really engineering, such contractors may be said to be applying so much more engineering to their work.

"I never undertake any concrete work," said one contractor, "without first calling up the Weather Bureau and asking what the forecast is. Never pour any when a cold wave's coming."

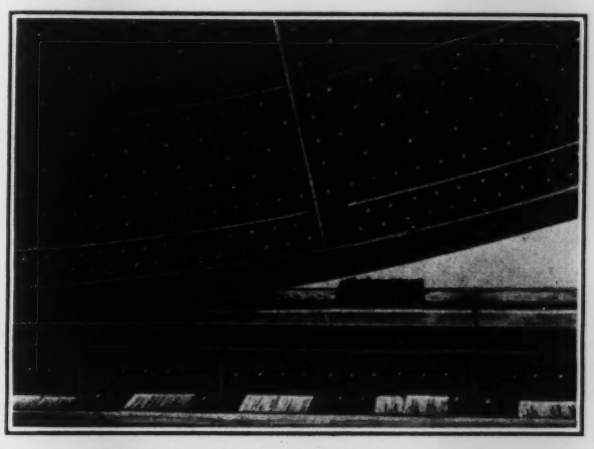
That man has the right idea, but even he could plan his work more intelligently if he would arrange to get the service map which is published daily at the Weather Bureau offices and which shows temperature and pressure conditions. These maps are furnished by the government for a trifling sum, and they enable the person who studies them and follows the storms across the country to learn to make his own forecasts for his particular locality several days ahead and with surprising accuracy.

This sort of prognostication—which should be supplemented and corrected, of course, by the daily bulletins of the Weather Bureau—is easy: just observe the directions which weather changes usually take across the country and notice what seems to be coming. Recently for example, fairly pleasant winter weather prevailed in central Ohio and the forms were ready to receive concrete for a certain bridge abutment. But the weather map showed zero in Nebraska, and Thursday's prediction said "much colder Friday night." No concrete was placed, so when, sure enough, the mercury did drop nearly to zero, the contractor was free from worry.

Other examples might be given of the value of the weather reports. But study of the charts, and of additional information published in the newspapers, announced by radio, or obtained directly by calling the Weather Bureau, should enable a prudent man to be ready for any storm that comes along and to take full advantage of propitious days. If understood, the weather man will be found a valuable ally of the contractor and engineer.

Bridge Repaired by Welding

IN the double-leaf Scherzer rolling-lift bascule bridge which carries the Baltimore & Ohio Chicago Terminal R.R. over the Chicago River, breakages have occurred from time to time in the curved flange angles of the heel or rolling girder, but the bridge could not be left closed or open for a sufficient time to allow of cutting out and replacing the broken portions with new riveted angles. In this rolling girder the curved face has two heavy flange or chord angles riveted to the web, as shown in the accompanying view. The track plates which form the curved wearing or rolling surface are bolted to the horizontal legs of the angles. With the vibration and jar of operation, cracks developed along the root of these angles. To remedy this defect, the breaks are filled and the broken horizontal legs of the angles built up by electric-arc welding, this work being done as trouble develops and without interfering with the operation of the bridge. By using the stable-arc process, which localizes the heat, there is said to be no loosening of the adjacent rivets in the vertical legs of the angles.

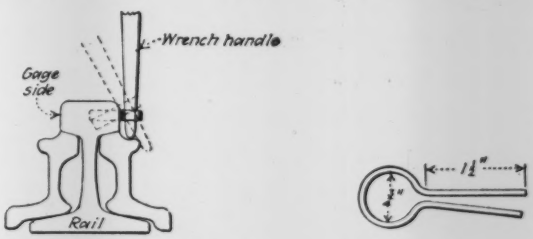


WELD REPAIRS ON FLANGE ANGLES

This rapair work was done by the Mitchell Co., Chicago, under the direction of H. A. Field, assistant engineer of bridges, Baltimore & Ohio Chicago Terminal R.R.

Expansion Shim for Laying Rails

A NEW device to insure proper joint spacing in laying rails is the Cotter expansion shim, shown in the accompanying drawing. The ordinary form of shim is an L-shaped steel plate of proper thickness, inserted in the top of the joint, one leg lying on the rail head so that it is easily seen and the shim is not likely to be left in place. But when the joint is bolted up it is often difficult to remove the shim. The new device is made in the form of a spring cotter and is inserted on the outer side of the track, fitting between



THE COTTER RAIL-LAYING SHIM

the rail heads. To withdraw it, the handle of a wrench is slipped into the ¾-in. ring and levered against the rail head, as shown, the shim being thus removed easily, even when tightly gripped.

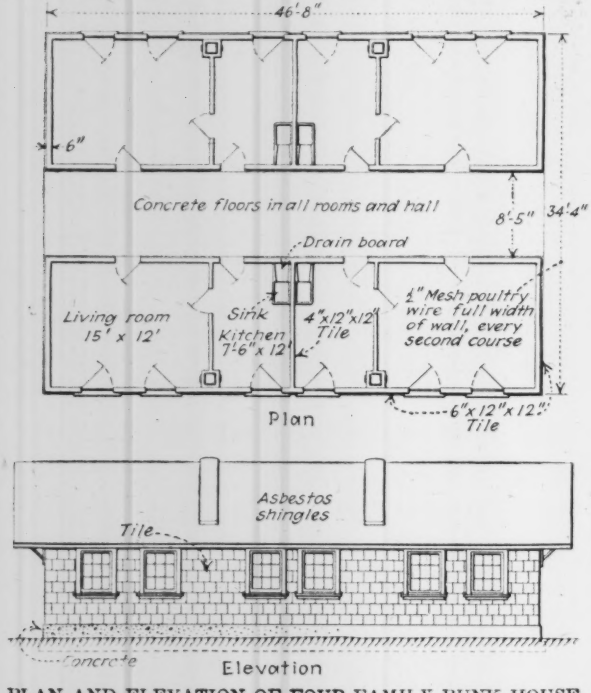
The cotter is ½ in. wide and is made in four thicknesses for different spacings: No. 1 is of ⅛-in. metal; No. 2, 1/16-in., No. 3, 1/32-in. and No. 4, 1/64-in. Thus, when closed together they give rail joint spacings of ⅛, 1/16, ¼ and 1/32 in. respectively. A table of expansion spacings has been prepared for use with this device in laying rails of different lengths. For the extreme temperature of 20 deg. below zero a 1/32-in. filler is used in addition to the thickest shim, while for high temperatures the thinnest shim is used and is placed only at every second to eighth rail joint.

The Cotter expansion shim, which has been used in

service, is the invention of Hunter McDonald, Nashville, Tenn., chief engineer of the Nashville, Chattanooga & St. Louis R.R. It is manufactured by the American Nut & Bolt Fastener Co., Pittsburgh, Pa.

Section Headquarters on New Southern Pacific Line in Arizona

IN building the new line of the Southern Pacific R.R., recently completed in Arizona, twenty-two sets of section headquarters were required. Eighteen of these



PLAN AND ELEVATION OF FOUR-FAMILY BUNK HOUSE

were constructed complete and ready for occupancy at an average cost of $10,650. This cost included one section foreman's house; two 4-family bunk houses with cement floors, tile walls and an open central hallway; one sunshade for washing and one tool house, together with all incidentals such as well, 1½-hp. pumping engine, 3,000-gal. tank on 30-ft. steel tower, fences, etc.

Four sets of section headquarters which included, in addition to the above, a signal maintainer's house and tool house were built at an average cost of $13,950.

From Job and Office

Hints That Cut Cost and Time

Equipment Worth $1,000 per Man Employed on Rush Earth-Fill Dam Job

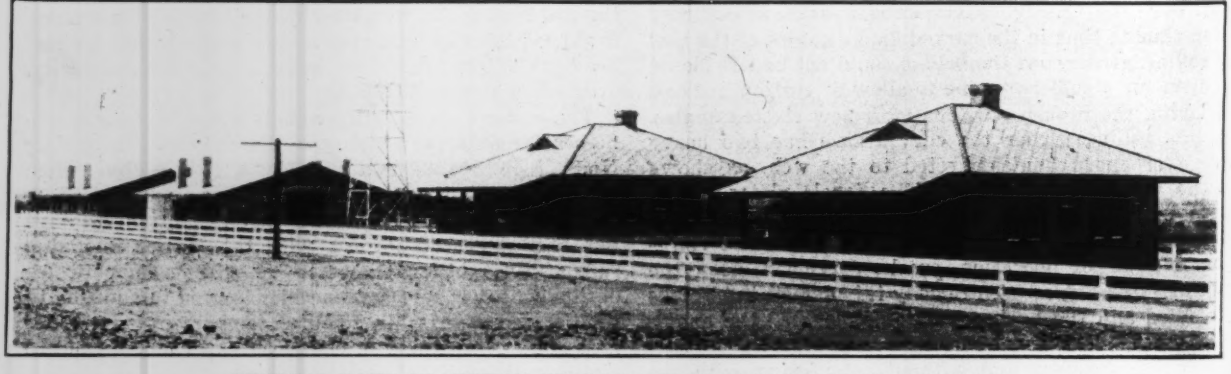
THE Philbrook dam, a rolled earth fill, recently built for the Pacific Gas & Electric Co., is located at El. 5,300 on the west branch of the North Fork of the Feather River, 50 miles northeast of Chico, Calif. The dam is 90 ft. high and its contents total 142,000 cu.yd. The capacity of the reservoir is about 5,000 acre-ft. which is to be used as storage for a chain of power developments below.

In the construction of this dam it was found desirable to use earth-moving equipment to an unusual extent in order to complete the work before the rainy season began. This has drawn attention to the job in comparison with work of the same character done ten years or more ago and it is being pointed out that although the yardage of earth moved per man employed has been very greatly increased, there has been an advance in even greater ratio in the value of equipment per man. More than $125,000 worth of equipment was used on the Philbrook dam whose entire crew for two 9-hr. shifts, including cooks, superintendent and, in fact, all the crew connected with the work in the field, totaled 125 men. That is, the equipment was worth $1,000 per man employed. This crew moved a maximum of more than 3,000 cu.yd. per day and averaged about 2,500 cu.yd.

The material of which the dam was built had to be moved on an average about 1,600 ft. The equipment included two gasoline-operated power shovels with 1½-cu.yd. buckets; six trucks of capacities ranging from 4 to 6 cu.yd.; three crawler tractors, each hauling two wagons with an average capacity of about 6 cu.yd. per wagon, and four power scrapers of a type recently developed in the West.

The two power shovels were used to load the trucks and tractor wagons at pits where the depths of deposits of suitable material exceeded 6 ft. They were also used for excavating the foundations of the dam including much of the core trench.

Much of the yardage required for the dam needed only to be loosened up in the borrow pits with a heavy



GENERAL VIEW OF SECTION HEADQUARTERS ON NEW LINE IN ARIZONA
Front line of the houses is 100 ft. from the main-line railroad. Foreman's houses at right; 4-family Mexican houses at left.

From Job and Office

For Contractor and Engineer

scarifier, after which it could be taken out with scrapers. When delivered into place on the dam successive layers of material were compacted with petrolithic rollers, four

PLACING MATERIAL IN THE PHILBROOK DAM
Core trench in right background. Each layer of the fill was compacted with the petrolithic tampers.

of which were usually at work while material was being delivered.

The power scrapers used on this job are of a type operated in connection with a tractor which is equipped with a generator, belt-driven from the gasoline engine, for supplying current to operate motors on the scraper. The man who drives the tractor also operates the scraper by means of remote control switches which regulate the angle at which the power scraper is tilted for loading or dumping, and also controls a motor-driven telescoping movement of the sectional bowl during loading and unloading.

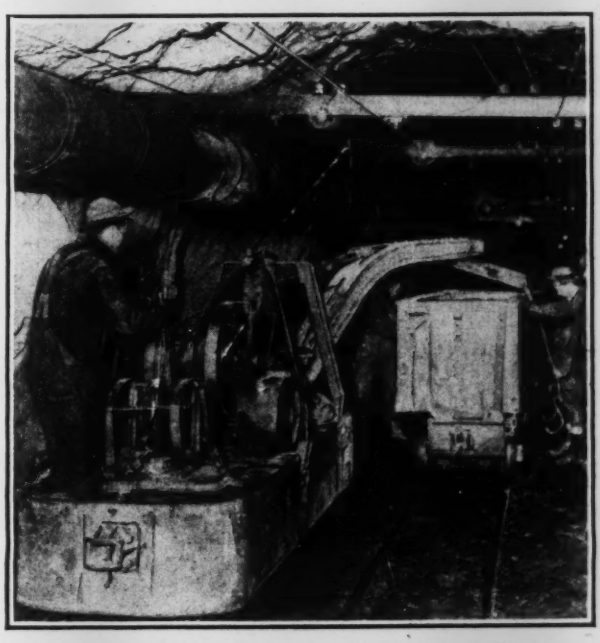
These scrapers were particularly well adapted to delivering material from the nearby borrow pits because they could dig, deliver and spread uniformly to any desired depth and also because, with the towing tractor, each one was a self-contained unit, not dependent upon a shovel or other additional equipment in order to maintain continuous delivery of material. They worked successfully in comparatively wet earth.

The contractor on the Philbrook dam was the Kaiser Paving Co., Oakland, Calif. The power scraper was developed and built by R. G. Le Tourneau, Stockton, Calif.

"Cherry Picker" Handles Tunnel Muck Cars

A HOME-MADE device known as the "cherry picker" is used for handling muck cars in the 8x9-ft. pioneer tunnel for the 8-mile Cascade Tunnel of the Great Northern Ry. This device, shown in the accompanying cut, was designed and built for this particular job. It is an air-operated crane mounted on a base with wheels traveling on the 24-in. construction track, compressed air being taken from the air line which supplies the drills. From the boom is hung a stretcher or short beam having rods with hooks which engage the frame of the car. The machine is not self-propelling but is moved by the haulage locomotive when it is necessary to shift it from place to place in the tunnel.

In operation, the crane picks up each empty muck car in turn from the incoming track and swings it over to the loading track, to be loaded by the mucking machine, which is mounted between the two tracks. A very heavy cast-iron frame is used, so that the crane can handle cars of 50 cu.ft. capacity without requiring any outriggers or jacks to support it.



"CHERRY PICKER" IN THE CASCADE TUNNEL

This tunnel construction, described in *Engineering News-Record*, Nov. 25, 1926, p. 858, is being done by A. Guthrie & Co., Inc., St. Paul, Minn., under the direction of J. C. Baxter, vice-president, with R. F. Hoffmark as general superintendent.

News of the Week

Current Events in the Civil Engineering and Contracting Fields

Fort Lee Bridge Discussed by New York Engineers

Five Papers on Port Authority Project Read at Am. Soc. C. E. Section Meeting

Five papers dealing with the bridge to be built across the Hudson River between Fort Washington Point in New York City and Fort Lee, N. J., by the Port of New York Authority were read at the meeting of the New York Section, American Society of Civil Engineers, on Feb. 16. Four of the papers were presented by members of the Port Authority engineering staff. O. H. Ammann, bridge engineer, described the main features of the project as a whole; Robert A. Lesher, traffic engineer, outlined the traffic studies by means of which the financial feasibility of the project was determined; W. J. Boucher, engineer of construction, sketched the triangulation procedure; and Allston Dana, engineer of design, gave some of the data involved in the calculations for the bridge. Following these papers, R. S. Buck challenged the design as to a number of its major features, and called for a thorough reconsideration and restudy of the project.

HISTORY OF CROSSING PROJECTS

Mr. Ammann outlined the history of Hudson River bridge crossing projects, which goes back more than fifty years, and suggested that the political and economic problems involved are today much greater than the engineering problems. The latest stages, as generally known, are that in 1925 the legislatures of New York and New Jersey authorized the Port Authority to build a Hudson River bridge between 170th and 185th Sts., that a year later the Port Authority reported the project feasible, technically and financially, that the legislatures then appropriated $1,000,000 each as the first five installments, to be repaid from tolls, and that three months ago the Port Authority authorized a $60,000,000 bond issue and soon afterward sold the first $20,000,000 of this issue on favorable terms. The traffic expected is 8,000,000 vehicles in 1932, and twice as much in 1950. For the first few years four traffic lanes are likely to be sufficient, and thereafter the capacity of the bridge may be increased.

The bridge to be built has a main span of 3,500 ft. and side spans of 650 ft. each, the latter determined by the nearness of the Palisades cliff on the New Jersey side. The west anchorage is made by means of tunnels in the rock, the east anchorage by a masonry anchorage mass founded on rock. The New York tower is founded on rock above water, the New Jersey tower on rock at about 100 ft. below water. The vertical clearance at mid-span is 200 ft. The suspension system comprises two chains, which may be built either of eyebars or of wire cables, whichever proves cheapest in competitive bidding. The stiffening truss is below the cables, and is of very shallow depth, being intended for local distribution only.

In the first stage of construction, when only part of the floor width would be constructed, the stiffening trusses would not be erected; they would be placed as part of the second or completing stage of construction. The cables are also arranged for two-stage construction. In the case of wire cables, there would be on each side two cables of 37-in. diameter, the lower to be built in the first stage and the upper in the second stage; in the case of eyebars there would be on each side eight chains of twelve bars each, the four lower chains to be built in the first stage.

The towers, which are about 650 ft. high, are designed as braced steel towers with concrete encasement of the steel to form a masonry-faced concrete shell. The flexibility of these towers would be sufficient for the necessary cable movement, which in view of the short land spans would not exceed 10 in. horizontal movement at the top.

Figures given by Mr. Dana include the following: The load on the top of each tower in final stage would be 280,000,000 lb. and the load just above the tower base 620,000,000 lb. The rock pressure would amount to 24 tons per square foot, or with tower bending about 33 tons per square foot. The bridge has a ratio of live-load to dead-

Heavy Seas Damage North Atlantic Coast Resorts

An unusual moon tide, coupled with a storm driving from a general northeast direction, did several million dollars worth of damage to North Atlantic seacoast resorts and cities, Feb. 19 and 20. Greatest damage of engineering interest was sustained at Long Beach, Long Island, where a number of timber groins under construction or just finished, were battered down or wrenched apart. These groins were generally normal to the shore line and extended several hundred feet seaward from high tide line. They were built of oak piles set on 4-ft. centers with 3x10-in. dressed and treated timbers for filling. Pieces of 6x8-in. timber were bolted through the piles at the top. Piles had an average penetration of 18 ft. A group of houses also was undermined by the heavy sea and toppled over.

Losses along the Jersey beach were relatively slight. About 200 ft. of Ocean Boulevard at Monmouth Beach were undermined; and one house each at North Long Branch and Seabright were lost. The principal damage was to light bulkheads and boardwalks in front of summer residences.

The damage at Coney Island was slight, and that at two principal Staten Island beaches consisted in loss of numerous small summer and year-around bungalows.

Details of the structural damage will be included in a later issue.

Rain Causes Heavy Damage in California

Storm Loss in Los Angeles County May Reach $1,000,000—Colorado in Flood

Heavy rains all along the California coast that continued for several days culminated on Feb. 15 and 16 in floods of serious proportions, particularly in southern California.

Near Whittier a railroad bridge across Puente Creek went down under the weight of a Union Pacific passenger train, killing the locomotive driver. This bridge is a 150-ft. steel truss with two 60-ft. girder approach spans.

Telegrams received Feb. 22 from Los Angeles reported no damage to city's new concrete bridges or other important structures, although two or three old timber bridges on Los Angeles River went out as did 50 ft. of Glendale Boulevard bridge. No permanent street pavements were destroyed. The Pacific Electric Ry. lost its Los Angeles River bridge on the Glendale line. All county flood control dams and channels were reported in good condition. There was much damage to residences by the inundation of about eighty city blocks in lowlands, some of which had no levee protection; also much damage to old county bridges and state highways, due to landslides and swollen streams. It is estimated that the storm damage in Los Angeles County may reach $1,000,000.

A telegram to this journal from the San Diego city manager reported that washouts destroyed about 500 ft. of concrete flume below Hodges Dam and 800 ft. of 18-in. wood-stave pipe near Delmar. However, the total damage to San Diego property was estimated under $40,000. No damage was sustained by the Otay pipe line or by any of the dams and all city reservoirs are now filled, giving the city five years' water supply without more rain.

Telegrams from Yuma reported that on Feb. 21 the Colorado River flow reached a maximum of 100,000 sec.-ft. and the entire river was passing through the unrepaired 1926 break in the levee seven miles below the head of the Pescadero Cut. On the afternoon of Feb. 21 the river was falling and the crest of the flood had passed.

In Southern Oregon landslides incidental to the highest floods in thirty years blockaded the main line of the Southern Pacific R.R. and it was still unopened on Feb. 22. However, no serious storm damage to important structures was reported anywhere on the Southern Pacific system.

load equal to 16 per cent, as against 46 per cent for the recently completed Delaware River bridge. The bridge is stiff enough due to the weight of cables and floor to require no stiffening truss for damping the major motions of cables and towers; the truss is provided only to limit local kinking. The lateral truss is proportioned with due regard to the lateral effect of the cable deflection, and it is found that the truss movement is only one-eighth the simple beam moment.

Major Buck, taking the negative of the argument, urged that the engineers' attitude of mind that there are no unusual engineering or construction problems might impede the success of the undertaking. He also argued that the case is one where the value of competitive designs by various engineers should be taken advantage of. He expressed the belief that the design requires more consideration, and suggested that the urge to make progress toward the bond selling and contract letting stage might have hurried the work. In particular, he suggested that more openminded consideration should be given to the following elements: (1) The question of stage construction, subsequent enlargement as here proposed having never been done before; (2) the length of the land spans with a view to lengthening the New York land span in order to economize in approach and avoid blocking city streets; (3) placing the bridge roadway on a grade upward from the New York to the New Jersey end, rather than aiming at perfect symmetry; (4) using a shorter panel length between suspenders than 60 ft.; (5) the use of wire cables in place of chains, which latter appeared to have been given most favorable consideration in the design, although wire cables have considerably less of the experimental in their construction than do chains, are more perfect in their stress distribution, and are more permanent, besides being less subject to temperature variations and of more thoroughly assured quality in view of the test of metal quality which is furnished by the wire drawing process; (6) the design of the towers, which in the composite form proposed involves excessive load and cost and various structural uncertainties, as compared with steel towers of the Manhattan bridge type. Major Buck argued that honest masonry is impracticable for these towers and pseudo masonry is out of place both esthetically and structurally.

There was little opportunity for further discussion on account of the lateness of the hour. Harold M. Lewis brought out that the studies of the Regional Plan Commission closely check the estimates of expected traffic made by the Port Authority engineers. The Regional Plan Commission is strongly in favor of a bridge at the Fort Lee site, not merely because of present traffic needs, but even more because of its important relation to the future development of the region. The traffic volume on all the routes to the north and east of the city will in 50 years be so great that a cross-river link in the Fort Lee neighborhood will be a vital necessity in moving this traffic.

Atlantic States Highway Officials Meet

Nearly 2,000 Members and Visitors Discuss Three-Day Technical Program

Engineering News-Record Staff Report

Approximately 2,000 highway officials and employees and men connected with highway industries, met last week in Atlantic City, at the convention of the Association of Highway Officials of the North Atlantic States. The actual registration was between 1,400 and 1,500 and there were perhaps half a thousand more who as guests and visitors did not formally register. The representation was unusual, of all classes and ranks of men engaged in public road work. The heads of departments of one state had brought to the meeting virtually every engineering employee from inspector to chief engineer and commissioner. Fewer numbers came from other states of the association but the range in rank was as great. County and township road officials were numerously represented. In general the attendance at sessions ranged from 300 to 600.

There were five sessions, three of which were taken up chiefly with papers and discussions on traffic surveys, traffic regulation and location economics as affected by traffic. Two sessions were, in substance, experience meetings, one on concrete pavement experience and practice and one on outstanding projects or problems, in which each state in the association contributed its item of discussion.

Traffic Problems

Enormous turnover in managerial personnel such as occurs almost every two years in state highway departments would never be tolerated by private industry, J. G. McKay, chief of the division of highway economics and transport, of the U. S. Bureau of Public Roads, told the convention. He said that the frequent changes in the management resulted in a disruption of the work in the highway department and recommended the establishment of a definite plan of highway improvement extending over a period of years and approved by the legislature of the respective states as a legal plan. Mr. McKay declared that in the last few years highway transportation has grown from a position of comparative unimportance to a position of first rank in the national scheme of transportation, and that a thorough knowledge of future traffic requirements was of utmost importance to every highway department.

A highway department, he said, without a thorough knowledge of present and expected future traffic on its highways is like a ship without a compass. There is no fundamental difference in principle between the public business of developing systems of highways, and private enterprise engaged in producing commodities, or in the performance of services. The history of modern development and expansion of industries is largely a development based upon a careful analysis of the demand for products by present and potential consumers in a given area. The same basic economic and engineering principles of management that exert such a controlling influence in the field of private business should govern the public business of production in the highway field.

The location and improvement, or lack of improvement of a given area, Mr. McKay said, is of vital importance not only to the traffic of the immediate area but also to the traffic of larger areas. Therefore, the development of a system of highways should not be judged in miles and types of highways constructed each year, but considered in terms of the movement of peoples and goods.

The major problem confronting a highway department should not be one of the particular type of materials to use, but rather whether to build or no and how much highway service should be furnished in a given area. Upon the proper solution of this problem depend the well-being and progress of the people. Considering the improvement of highways from this point of view, there can be no question concerning the necessity of developing sound plans for highway improvement over a period of years in the several states, and of providing the necessary money to carry out economically the proposed plan of improvement.

Applied to the public business in a state, responsible for developing a connected system of improved highways, Mr. McKay said the first basic principle of production management is that the various sections of the highway system selected for improvement should be based upon present and expected future traffic demands. The second principle was that of the budget. Two important factors should be taken into consideration in determining the budget. First, the amount of money required to complete the improvement, and second, the apportionment of the cost among those who benefit by the improvement.

Automatic traffic signal lights were assailed by John A. MacDonald, commissioner of highways of Connecticut, as "the most objectionable impediment to traffic" that traffic engineers have to contend with. Mr. MacDonald said that a little over two years ago the traffic doctors believed they had found a remedy for "the disease of congestion" in the so-called "stop-and-go" light, but in reality they have served to "make the disease worse than it was before."

Mr. MacDonald declared that he believed the first and major move in traffic regulation is to do away with a certain portion of traffic lights and to revert to the use of traffic policemen.

The speaker further declared that the basic difficulties in traffic regulation lie in the fact that regulations are devised to make the unruly driver behave, and as a result a bigger class of good drivers are penalized by numerous restrictions. He urged fewer regulations and more drastic punishment for violations.

This part of the program closed with a notable paper by Fred Lavis on an economic theory of highway location

(*Continued on p. 339*)

Moffat Tunnel Water Bore Holed Through

President Coolidge Presses Key to Fire Final Round of 24 Shots

The pioneer bore of the Moffat Tunnel was holed through at 8:10 p.m. Friday, Feb. 18 when President Coolidge pressed the telegraph key which fired the final round of 24 shots. The report was broadcast from Crosscut 13. On Saturday construction tracks were connected between the east and west portals and natural ventilation secured through the pioneer or water tunnel. The railroad tunnel (main tunnel) headings had 1,765 ft. to go, and the enlargement to full section was incomplete for 5 523 ft. at the time of holing through the water tunnel. The contract calls for completion July 20, 1927.

Ground was broken on Sept. 20, 1923, by the Moffat Tunnel Commission. The tunnel is 6.1 miles long and thus is the longest railroad tunnel on the American continent. The pioneer or advance heading, 8x8 ft. in section, is parallel to and 75 ft. south of the 16x24-ft. railroad tunnel and will be connected to it by 20 crosscuts. The east portal is in solid granite and gneiss, but the west portal goes through more than 2 miles of soft rock, shattered gneiss and schist, which delayed the work, made necessary more and heavier timbering than was expected and greatly increased the cost, which will exceed $12,500,000 or more than twice the advance estimate.

The work is financed by bonds secured by the Moffat Tunnel Improvement District, comprising Denver, Grand, Moffat, Routt and portions of Eagle, Gilpin, Boulder, Adams and Jefferson Counties. The commission has leased the railroad tunnel to the Denver & Salt Lake R.R. Co.

The Moffat Tunnel is 50 mi. west of Denver and pierces the Continental Divide 3 mi. north of James Peak at an elevation at the tunnel apex of 9,242 ft. It will eliminate 30 mi. of 4 per cent grade over the Divide, and with the proposed Dotsero Cutoff will shorten the distance between Denver and Salt Lake City by 173 mi.

W. P. Robinson is president of the Moffat Tunnel Commission and George Lewis is general manager. C. A. Betts is office engineer and in charge of surveys, B. G. Coy is resident engineer at the east portal, and J. F. Cohig resident engineer at the west portal. The contractor is Hitchcock & Tinkler, Inc.

Bill Proposes $12,000,000 for Montreal Harbor

A bill has been introduced in the Canadian House of Commons, providing for an expenditure of $12,000,000 on the Montreal harbor. The money is to be spent as follows: Dredging, $800,000; wharves, piers and basins, $5,400,000; plant and equipment, $155,000; shops and buildings, $322,000; rails and electrification, $1,342,000; permanent sheds, $300,000; grain elevators, $3,155,000; also a total of $142,000 for small harbor works.

Thomas J. Skillman, New Chief Engineer of Pennsylvania R.R.

Thomas J. Skillman, whose promotion to be chief engineer of the Pennsylvania Railroad System was announced in *Engineering News-Record*, Feb. 3, p. 210, was born at Trenton, N. J., on Nov. 6, 1876, and graduated from Princeton University in 1898 as a civil engineer. After an enlistment of approximately nine months with the first U. S. Volunteer Engineers in the Spanish-American War, he entered the service of the Pennsylvania R.R. as a blueprint boy in March, 1899.

In May of the following year he was transferred to the engineer corps in charge of the track elevation work through Newark, N. J. In April, 1902, he was transferred as transitman to the office of the principal assistant engineer at Altoona, Pa., and in February of the following year was promoted to be assistant supervisor of the Tyrone division at Tyrone, Pa. The following year he was transferred to the Philadelphia division and in August, 1905, was promoted to be supervisor of the Pittsburgh division at Uniontown, Pa., in charge of the lower end of the southwest branches. Four years later he was transferred as supervisor on the Monongahela division at Dravosburg, and in November of the same year, 1909, was transferred to New York as supervisor in charge of track construction on the Pennsylvania Tunnel & Terminal R.R.

On June 16, 1913, Mr. Skillman was appointed division engineer of the New York, Philadelphia & Norfolk R.R., with headquarters at Cape Charles, Va. In December, 1914, he was transferred to the West Jersey & Seashore R.R. and Camden terminal division at Camden, N. J., as division engineer and in April, 1917, he returned to the Monongahela division as division engineer, Pittsburgh. In July of the same year he entered the office of the general superintendent of the New Jersey division at New York with special duties in connection with the study of terminal development at New York. On Oct. 1, 1917, he was promoted to be division engineer of the New York division at Jersey City and on Nov. 10, 1919, was made principal assistant engineer, Eastern Pennsylvania division, at Altoona, which position he retained under the United States Railroad Administration and until the termination of federal control in March, 1920, when he was appointed chief engineer of maintenance-of-way, northwestern region, with headquarters at Chicago.

Upon the consolidation of the northwestern and southwestern regions in June, 1920, Mr. Skillman became chief engineer of maintenance-of-way, western region, and on April 1, 1926, he was promoted to the newly-created position of assistant chief engineer with headquarters at Chicago, Ill. He was transferred to the Long Island Railroad Co. on July 6, 1926, as chief engineer.

Connecticut Engineers Hold Two-Day Session

Civil Engineers Meet for Discussion of Both Local and General Engineering Subjects

(Engineering News-Record Staff Report)

Members of the Connecticut Society of Civil Engineers to the number of about 200 met at New Haven, Conn., Feb. 15-16 for the 43d annual meeting of the society. As at last year's meeting, the lecture rooms of engineering laboratories at Yale University were put at the disposal of the society to the great convenience of the speakers as well as of the members.

Tuesday morning was devoted to society business, reports and election of new officers. Vincent B. Clarke of Ansonia, was elected president, and George E. Hamlin of Hartford and E. I. Rudd, vice-presidents. Clarence M. Blair was re-elected secretary and treasurer. J. P. Wadhams, retiring president, and H. J. Tippet were added to the list of directors.

The afternoon session was given over to a paper on X-ray investigations upon the structure of engineering material by Prof. George L. Clarke, divisional director, research laboratory of applied chemistry at Massachusetts Institute of Technology, and informal discussions of the New Haven sewage disposal problem by George W. Fuller of New York. Mr. Fuller stated that he was handicapped in what he had to say by the fact that the report of his firm to the city of New Haven on the subject of its sewage disposal problems had not been formally presented. He added, however, that he could state that his firm was recommending sedimentation to remove solid, chlorination of the effluent, and that the sludge be taken to sea for disposal.

Professor Clarke gave an informative talk on the use of X-ray in determining the crystalline arrangement of the structure of engineering materials and showed that in a study of metals the X-ray went so much deeper into the structure than the microscope that it was possible to show a distinct difference in the arrangement of the crystals which was not shown by the microscope, and that by this means it was possible to determine whether internal strains existed and other matters of great importance in such materials.

At the annual banquet held on Tuesday evening, General John F. O'Ryan, president of the Colonial Air Transport Co., and Col. L. F. Horner spoke on commercial air transportation.

Wednesday morning was given over in part to a business meeting and in part to the presentation of three papers, one on modern bridge erection by William G. Grove of the American Bridge Co., which included a description of the erection method used in the eye-bar suspension bridge at Florianopolis, Brazil; one by Caleb Mills Saville, manager and chief engineer, Board of Water Commissioners, Hartford, Conn., on the future water supply of the cities of Connecticut, and a paper entitled "Investment Versus Present Values; Conflicting Basis for Return to Public Service Corporations,"

by Winthrop M. Daniels, Thomas DeWitt Cuyler Professor of Transportation, Yale University. Mr. Saville stated that while there was sufficient water for the next 50 years from upland and underground sources in Connecticut, yet the method of acquiring and controlling such sources was so unsystematic that he recommended state regulation by a special commission whose chief duty should be to allocate such water-gathering ground to the various communities.

At the business meeting the Society took steps to favor the passage of the state re-survey bill which is now before the legislature. The bill calls for the complete re-survey of the state of Connecticut in co-operation with the U. S. Geological Survey, the work to be completed in five years. The new map will be on a scale of 2 in. to the mile and will be the first state map to be done upon this larger scale.

Atlantic States Highway Officials

(*Concluded from p. 337*)

developed on the basis long known to railway location engineers.

In a report on observations on concrete pavement under various specifications and conditions imposed by the North Atlantic States, J. S. Bixby, division engineer, New York State Bureau of Highways, discussed a crack and corner break survey of some 2,500 miles of concrete roads in New York, New Jersey, Delaware and the New England states. This report had many charts and some of these with a precise statement of conclusions will be summarized in a succeeding issue. In discussion C. D. Buck of Delaware, spoke of cross-joints and took the position that the fewer there were of them the better. In Delaware they were placed only at the end of a day's run. The way to avoid cross cracking he said, was to build a precise subgrade. W. M. Achison, New York, spoke particularly of the influence of materials on cracking, corner breaking and scaling. He stressed exactness and strictness in accepting sand and aggregate. Sand, he said, was the critical material and caused most trouble. Scaling he considered came mostly from excessive working of the surface in finishing the road and therefore gravel concrete, needing less working, frequently developed less scaling. In this connection the report later by H. E. Breed on the Syracuse test road was largely a survey of cracks and corner breaks. It was too soon, considered Prof. Breed to draw fine conclusions but it seemed indicated that in resurfacing old concrete there was hazard in using less than a 4-in. topping.

Among the outstanding state projects cited were the vehicular tunnel road through Jersey City, the topping and widening of the Boston Post Road, sand asphalt roads in Delaware, tar treated gravel roads in Maine. All of these have been described in *Engineering News-Record*. The meeting closed with an interesting paper by Paul D. Sargent, Maine, reporting the experience of the American delegates to the 1926 international road congress which was held at Milan, Italy.

Personal Notes

PATRICK QUILTY has been appointed borough engineer of Manhattan, New York City, to succeed JOHN W. MCKAY, who has recently become deputy chief engineer of the Department of Water Supply, Gas & Electricity of the same city. Mr. Quilty has served New York City in various engineering capacities since 1904, when he began work as rodman in the Borough of Richmond. From 1906 to 1920 he served on the construction of high-pressure and low-pressure water mains. From 1920 to 1924 he was engineer of the Bureau of Subway Conduit Construction, New York City, and since 1925 he has been supervising construction engineer of water mains, Borough of the Bronx.

G. D. EDDY, formerly with the president's conference committee of Chicago, has been appointed valuation engineer of the St. Louis-San Francisco Ry. to succeed C. B. SPENCER, who resigned after twenty-five years of service with the Frisco System. Mr. Eddy, a native of Canada, was educated at Malone Academy, Malone, N. Y. He began his railroad career as a rodman for the New York & Ottawa R.R. in 1897. In 1898 he became assistant engineer for the Muscatine North and South Ry. Co. Subsequently he served several railroads in engineering capacities until he joined the Northern Pacific. In 1919 he became valuation engineer for the Great Northern.

W. C. RECORD has resigned as city engineer of Fullerton, Cal.

HARRY SCOVILLE, city manager of Monrovia, Cal., has resigned. He was president of the city manager's section of the California League of Municipalities.

ALFRED M. LUND, Little Rock, Ark., announces the formation of the Lund Engineering Co., successor of Alfred M. Lund, civil engineer, with the following personnel: Alfred M. Lund, president, George E. Garanflo, vice-president, C. Ben Hoech, field engineer.

JOHN A. WHITING, state engineer of Wyoming, has been appointed by Governor Emerson to act also as interstate streams commissioner, succeeding S. G. Hopkins, resigned, in interstate conferences on the distribution of the waters of the North Platte River between the states of Colorado, Nebraska and Wyoming.

WARREN E. HICKS, of Warren, Ark., has been made resident engineer for the Arkansas State Highway Department, with headquarters at Harrison, Ark.

WENDELL P. BROWN of Cleveland has been selected by the board of commissioners of Lorain County to act as consulting engineer in connection with the erection of the memorial bridge over Black River in Lorain. The improvement will cost more than $2,000,000.

JAMES L. HARROP, for the past fourteen years chief valuation engineer for the Missouri Public Service Commission has tendered his resignation effective on March 5. He has accepted the post of valuation engineer for the Federal Water Service Corporation.

Engineering Societies

Calendar

Annual Meetings

AMERICAN RAILWAY ENGINEERING ASSOCIATION, Chicago, Ill.; Annual Convention, Chicago, Ill., March 8-10, 1927.

AMERICAN WELDING SOCIETY, New York; Annual meeting, New York City, April 27-29.

NATIONAL FIRE PROTECTION ASSOCIATION, Boston, Mass.; Annual Meeting, Chicago, Ill., May 9-12, 1927.

The Canadian Section of the American Water Works Association will hold its annual meeting March 2 to 4 at Ottawa. The secretary is A. V. Sanderson, superintendent of the Toronto filtration plant.

The Springfield (Ill.) Engineers Club, at a joint meeting with local civic clubs on Feb. 11, was addressed by Robert M. Davis, statistical adviser of the McGraw-Hill Publishing Co., on forecasts of industrial and economic conditions for 1927, with the methods of using such data by business firms.

Obituary

RUSSELL ROBB, engineer and senior vice-president, treasurer and a director of Stone & Webster, Inc., Boston, Mass., died Feb. 16 after a week's illness, aged 63 years. Mr. Robb was born in Dubuque, Iowa, in 1864, graduated from Massachusetts Institute of Technology in 1888 and three years later joined Stone & Webster. He became a member of the firm in 1905 and with its incorporation in 1920 became senior vice-president. Besides being a director of Stone & Webster, he was also director of several power and light companies. He wrote a number of books on business and engineering topics, one of which is now used as a textbook in the Harvard University Graduate School of Business Administration.

CAPTAIN C. ARNOLD MOHN, assistant county engineer, living at Arlington, N. J., was stricken with apoplexy Feb. 6 while riding in an auto and died that day, aged 35 years. Captain Mohn served with the 104th Engineers in the war and saw action in Chateau Thierry and Belleau Wood.

DEWITT V. MOORE, Indianapolis, Ind., died Jan. 30 of a heart attack. Mr. Moore was first employed by the Indianapolis Union Railway Co.; then became a member of the Moore-Mansfield Engineering Co., and designed many buildings and bridges. Later he went into the Moore-Halsted Construction Co. After five years of service as an engineer with the Interstate Commerce Commission at Chicago, Mr. Moore took up the work of sales engineer. He was a member of the administrative building council of Indiana.

Railroad Equipment and Materials

A Section Devoted to What the Manufacturer is Doing for the Engineer and Contractor

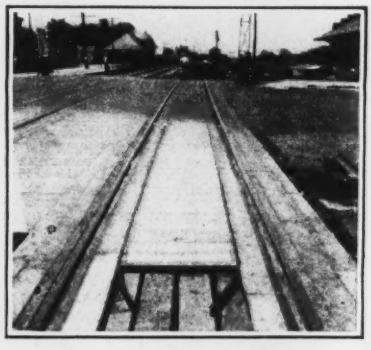
Railroad Show

From March 7 to 10 the National Railway Appliance Association will hold its annual exhibit at the Coliseum in Chicago in connection with the annual meeting of that association and of the American Railway Engineering Association. Among the many types of equipment which are to be on display will be a number of new ones. A few of these new devices are described below. Others will be described in subsequent issues.

Two New Types of Railroad Grade Crossing Pavement

Two new types of crossing pavement for grade crossings between highways and railways are to be exhibited at the Railroad Show. The first is by the Philip Carey Co., of Cincinnati, Ohio, and is called "Elastite Preformed Track Pavement." It consists of special sections of rail filler, preformed asphaltic slabs, and expansion joints, all sealed together with asphaltic cement so as to form a smooth riding, durable and watertight crossing. The rail filler is made to fit the web of the rail with which it is to be used, being forced into place by blows from a sledge, thereby sealing the crossing surface at the rail and at the same time providing a flangeway on the gage side and a guard on the outside. The slabs used are formed from a mixture containing asphalt, rag fiber, and mineral matter. They have no grain and therefore no tendency to warp or creep. The crossing can be installed with ordinary track tools.

The other crossing is made by the Locomotive Finish Material Co. of Atchison, Kan., and is similar to the metal crossings made by that company, except that it is of an extra heavy type and is constructed with a third supporting rail in the center of the track, thus cutting down the width of the span by one-half. The individual plates are only about 2 ft. square, approximately the size of the ordinary manhole cover used in streets, and are heavily reinforced with ribs on the under side so that they will stand up under any loads to which ordinary street pavement is subjected.

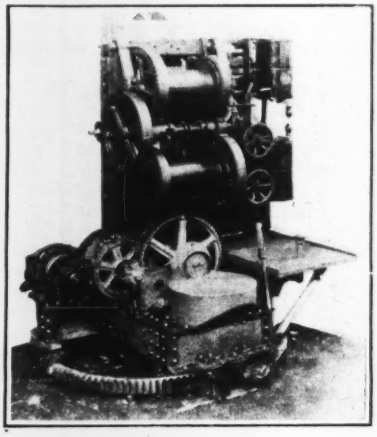


Smoke Jack Designed to Ventilate Inside of Engine House

An improvement over the old style of ventilating smoke jack for engine houses is being made by the Johns-Manville Co., New York. The jack is made almost entirely of flat sheets of "transite asbestos wood" and so arranged that the sections for the inside of the house can be assembled separately from those for the outside in order to facilitate erection. The jack uses the ejector pump principle for ventilating the under side of the roof of the engine house, but the concentric stacks of the older smoke jacks of this type, which were difficult to erect and maintain, have been eliminated. Instead, there are only two slots, one at each end of the opening through the roof. The sides of the roof opening and the vertical sides of the stack are in contact, and at that point the sides of the hood are continuous with the sides of the portion of the jack above the roof. The front and back faces of the upper part are turned outward to cover the slots in the roof opening and the corresponding sides of the hood are extended part way up into the upper enlarged section. Gases which accumulate under the roof when locomotives are being moved in or out of the stalls, or from improper "spotting" of locomotives, are drawn into the jack by the ejector action of the blast of a locomotive up through the restricted section. It is claimed that the material of which these jacks are built is practically indestructible and that they will outlast other types.

Platform Derrick Equipped with Electric Hoisting Machinery

An innovation in the ordinary platform derrick or pillar crane used around freight sheds and other places where heavy equipment has to be handled is the addition of electric crabs and slewing attachments to replace the hand winch. Such electric equipment is being added to cranes of this character by the American Hoist & Derrick Co. of St. Paul. The structural platform on which the slewing machinery is built is of heavy I-beams and angles. Upon it are mounted the reversible electric motor which actuates the slewing attachments and the gears and shafts which transmit the slewing power from the motor. All the controls are bunched within easy reach of the operator standing on the platform. A controller and resistance are furnished for both the slewing motor and the motor of the electric crab. The crab is the company's standard two-drum electric crab, designed to bolt to the mast of a derrick like a hand crab. It can be arranged for either direct or alternating current. The electric motor furnished with the crab is rated 7½ hp. and the slewing motor is rated at 5 hp.



Portable Acetylene Lighting Unit Reduced in Weight

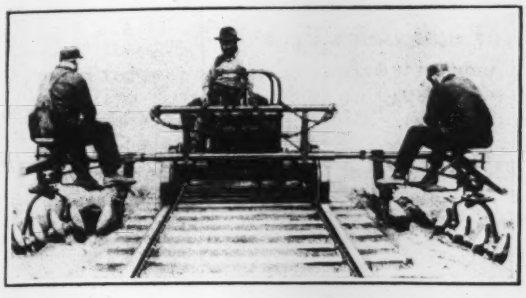
An addition to the line of carbic lights produced by the Carbic Manufacturing Co., of Duluth, Minn., is its No. 15. The height and diameter have been reduced somewhat from that of the standard style in order to increase its portability without unduly sacrificing its capacity. The light burns 9½ hr. instead of 12 as in the standard type. This is considered sufficient for ordinary nights. The light has the adjustable reflector arm of the larger type.

New Rail Anchor Exhibited

A recent development in rail anchors is to be exhibited at the Railway Show by the Bethlehem Steel Co., Bethlehem, Pa. This anchor is known as the Bethco rail anchor. It is adjustable and can be fitted to oversize or undersize rails. A description of it was given in our issue of Aug. 19, 1926, p. 319.

Disk Harrow Designed for Use on Railway Track Motors

A method of using disk harrows for agitating ballast outside the end of the ties on railroad tracks has been devised by the Northwestern Motor Co. The device is known as the Casey-Jones 580 ballast disker, the name Casey-

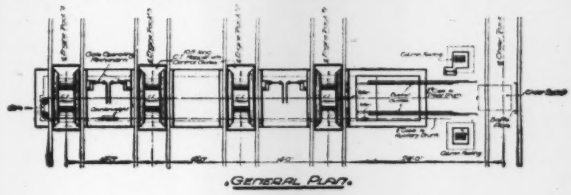


Jones being the same as applied to the railroad track motor cars made by that company. The ballast disker is designed to be propelled by track motors. By its use the ballast can be agitated to improve drainage and cut weeds, the shoulder can be shaped to the desired contour, and a definite grass line can be established easily. The disker can be used in all kinds of ballasts with heavy-duty motor cars equipped with standard Ford motors. It uses standard agricultural disks, and, according to the maker, has a low operating cost.

New Equipment for Handling and Reclaiming Cinders

An ash reclaiming plant developed in Germany and put into use there and in England during the last four or five years is being put on the market in this country by Roberts & Schaefer Co. of Chicago. The device is known as the Kolumbus coke separator. The separator works on the principle that a mixture of ordinary clay and water having a specific gravity of approximately 1.28 will cause coke and coal to float, but will permit rock, clinkers, and other heavy substances to sink. Ashes from railway cinder pits are first sifted to get out the fines and the residue then is fed into the separator where the coke and coal remain floating upon the surface and are removed by a screw conveyor while the waste material sinks to the bottom and also is removed by a screw conveyor. Results show that some 25 to 35 per cent of the cinders run through the separator may be recovered as combustible fuel with a calorific value of about 90 per cent of the original fuel.

At the Railway Show the Roberts & Schaefer Co. also is displaying a model of its multiple pit type of cinder handling plant for large terminals. Heretofore its "N & W" type cinder handling plant made by the company has not had sufficient capacity for use at large terminals. Details of a plant designed for four tracks are given in the accompanying drawing.



Manganese Steel Casting Protects Railway Switch Points

A device for protecting the points of railway switches, which differs somewhat from those now on the market, is being made by the Frog, Switch & Manufacturing Co., of Carlisle, Pa. It

consists of a cast manganese steel point, which is bolted to the ends of the swing rails of switches and takes the place of the narrow point of the ordinary switch points. As this casting becomes a part of the point rail it moves with it and so is swung away from the stock rail when the switch is not in use.

Standardized Columns for Steel Railway Water Tank

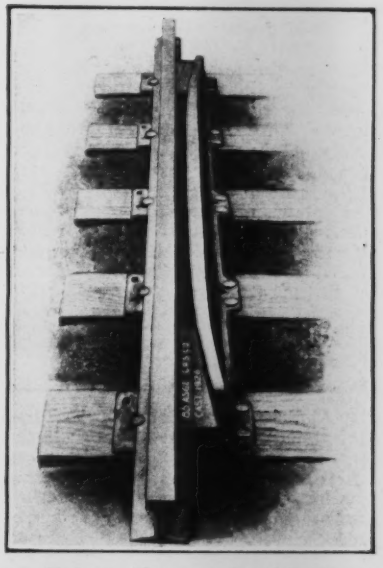
In order to speed up construction of its standard 50,000 and 100,000-gal. railway water service tanks, the Pittsburgh-Des Moines Steel Co., of Pittsburgh, Pa., has adopted an H-section column for supporting the tank. The

standard tanks have a height of 20 ft. to the bottom and so the columns and fittings can be fabricated and carried in stock ready for shipment. The illustration shows a tank for the A. C. & Y. R.R. which was completed within 60 days of the receipt of the order.

At the Railway Show the company will have an exhibit of a cross-section of the new columns for its water tanks and also one of its roadside tanks for the storage of oil in small quantities at section houses and similar points.

Improved One-Piece Guard Rail

An improved one-piece guard rail is being displayed by the Cleveland Railway Supply Co. at the Railway Show, along with other equipment of its



manufacture. The guard rail is of manganese steel. The hold between the guard rail and the main rail is obtained by heavy flanges extending under the main track rail and the sloped web

forms a substantial brace throughout the entire length on the inside.

Among other new equipment displayed by this company is an open trough flangeway guard for use in highway grade crossings with bituminous paving material, and a new rail anchor with a locking lug and wedge which makes it possible to adjust the anchor to variations in the rail section.

Manufacturers and Trade Associations

Calendar

Annual Meetings

NATIONAL RAILWAY APPLIANCES ASSOCIATION, Chicago; Annual meeting, Chicago, March 7-10, 1927.

NATIONAL BATTERY MANUFACTURERS' ASSOCIATION, New York; Annual meeting, Philadelphia, March 11 and 12, 1927.

CONCRETE REINFORCING STEEL INSTITUTE, Chicago; Annual Meeting, White Sulphur Springs, West Va., March 21-23.

SOUTHERN PINE ASSOCIATION; New Orleans; Annual meeting, New Orleans, March 22-23.

HYDRAULIC SOCIETY, New York; Annual meeting Chicago, March 25, 1927.

WATERWORKS MANUFACTURERS ASSOCIATION, New York; Annual meeting, Chicago, June 6-10.

Two Coast Cement Plants Effect $30,000,000 Merger

An agreement to merge the properties of the Pacific Portland Cement Co., Consolidated, and the Old Mission Portland Cement Co. into a California corporation to be known as the Pacific Portland Cement Co. with a capital of $30,000,000, has been announced by the presidents of the two concerns. Capital stock of the new corporation will be 300,000 shares.

Stock at the present time will be issued only to the two companies in exchange for their properties. These consist of three cement plants with a capacity of 15,000 bbl. per day, two large plaster and gypsum plants and thousands of acres of mineral land.

The plant of the Pacific Portland Cement Co. was the first in northern California and the old Mission company operated the first modern wet-process plant in that territory.

New Publications

Car-Retards for Gravity Yards—UNION SWITCH & SIGNAL CO., Swissvale, Pa., has issued a 90-page pamphlet (Bulletin 108) on "Modern Yard Operation," describing the construction, operation and advantages of electro-pneumatic car-retarders or track-brakes for controlling the movement of cars in gravity switching. Folding sheets show plans and profile of the installation in the Markham terminal yard of the Illinois Central R. R. at Chicago.

Business Side of Construction

Facts and Events that Affect Cost and Volume

This Week's Contracts—Week Ago—Same Week Last Year

THE money value of contracts reported in the present issue of *Engineering News-Record* is here compared with the figures for corresponding weeks. Minimum costs observed are: $15,000 for water-works and excavations; $25,000 for other public works; $40,000 for industrial and $150,000 for commercial, educational, religious and other buildings. Under the head of excavations are included drainage, irrigation, levee, river and harbor projects.

Money Value of Contracts Let—Entire U. S.

Week Ending	Public Work	Private Work	Total Contracts
Feb. 24, 1927	$10,742,000	$26,534,000	$37,276,000
Feb. 17, 1927	14,594,000	35,503,000	50,097,000
Feb. 25, 1926	10,278,000	27,116,000	37,394,000
Heaviest Week			
1926, Mar. 11	13,029,000	73,613,000	86,642,000
1925, Sept. 3	16,215,000	69,424,000	85,639,000
Jan. 1 to Date			
1927	107,889,000	248,969,000	356,858,000
1926	121,834,000	248,835,000	370,669,000

Railroad Building Most Active in South and West

Contract Figures For 1926 Show Ohio and Illinois in Lead in Number of Lettings—Prices of Railway Supplies Steady

EXAMINATION of all railroad construction contracts valued at $25,000 and over, awarded in the United States during 1926, shows that the bulk of the lettings were in the Southern and Western states. Of these, the major portion developed in the West. Massachusetts, New York and Pennsylvania were the only Northeastern states to show a measurable volume of railroad building.

Greatest activity in this branch of construction, as measured by number of projects awarded, was attained in Ohio and Illinois, with Mississippi and Missouri next, Alabama and California third, and Texas and Minnesota, fourth.

Principal among the big railway jobs of the year were the following: 180 mi. on the Chicago, Rock Island and Pacific R.R. in Kansas and Texas; 143 mi., Muscle Shoals, Birmingham & Pensacola R.R. in Mississippi, Florida and Alabama; 101 mi., Wabash R.R., Missouri; 100 mi., Union Pacific R.R., Nebraska.

Other projects ran into larger amounts of money but in those cases buildings, tanks, towers, etc., were included.

A comparison of prices of the principal railway supplies for the month of February, this year, a year ago, and in 1925, shows that firmness, with little tendency to change, prevails in the market for this group of materials.

Standard rails are perhaps the steadiest of the materials listed, considering the fact that railroad expansion was particularly active during the period 1922 to 1926. Throughout these boom years, the price stability shown by standard rails has been matched by few materials used in any form of construction.

Possibly the only other materials to show little or no change during the last four years are wrought steel and iron pipe, tin plates and wire rope, f.o.b. producing points.

(*See Table On p.* 343)

PRICES OF PRINCIPAL RAILWAY SUPPLIES F.O.B. IN CARLOAD QUANTITIES

	Feb., 1927	Feb., 1926	Feb., 1925
Rails, standard, Pittsburgh, per ton	$43.00	$43.00	$43.00
Rails, light, 25 to 45 lb., per ton	36.00	36.00@38.00	36.00
Rails, re-rolled, per ton	30.00@32.00	30.00@34.00	27.00@32.00
Ties, white oak, 6x8 in. x 8½ ft., per tie:			
Chicago	1.45	1.35	1.60
St. Louis	1.20	1.15	1.20
Birmingham	1.25	1.25	1.25
Spikes, standard, ⅞-in. and larger, Pittsburgh, per 100 lb.	2.80@2.90	2.80	2.90
Track bolts, Pittsburgh, per 100 lb.	3.90@4.25	3.90@4.25	3.90@4.25
Standard section angle bars, splice bars or fish plates, Pittsburgh, per 100 lb.	2.85	2.75	2.75@2.85

Principal Railway Construction Contracts Reported By E. N.-R. During 1926

Location	Miles	Awarded By	Awarded To	Date	Amount
Missouri	4	Terminal R.R. Assoc., St. Louis	By day labor	Jan., 1926	$650,000
Massachusetts	4	Boston and Albany R.R. Co	New England Constr. Co., Springfield	Mar. 1926	250,000
Nebraska	100	Union Pacific R.R. Co	By day labor	Mar., 1926	
Missouri		Missouri Pacific R.R. Co	List Constr. Co. and others	April, 1926	3,235,000
Missouri	101	Wabash R.R. Co	Industrial Track Constr. Co., St. Louis, Mo	May, 1926	490,000
California		Western Pacific R.R. Co	Eaton and Smith, San Francisco	May, 1926	200,000
Ohio		Central Steel Co., Massillon	F. A. Wendling Constr. Co., Massillon	June, 1926	500,000
New York		New York Central R.R. Co	Walsh Constr. Co., Davenport, Ia	June, 1926	975,000
Wisconsin		Milwaukee Electric Ry & Light Co	Company forces	July, 1926	320,000
Pennsylvania		Pennsylvania R.R. Co	Sinclair and Griggs, Philadelphia, Pa	July, 1926	1,840,071
Kansas and Texas	180	Chicago, Rock Island & Pacific R.R. Co	W. H. Dennison, Cushman, Ark	July, 1926	
Minnesota	6	Minneapolis, Northfield & Southern R.R. Co	Nolan Bros., Minneapolis, Minn	Aug., 1926	225,000
Minnesota		Minneapolis Street R.R. Co	By day labor	Aug., 1926	200,000
Ohio		Baltimore & Ohio R.R. Co	Bates and Rogers Constr. Co., Cleveland, Ohio	Aug., 1926	750,000
Massachusetts		Transit Dept., Boston Rapid Transit System Extension	A. G. Tomassello & Son, Boston, Mass	Sept., 1926	255,910
Massachusetts		Transit Dept., Boston, Sept. 3 Dorchester Rapid Transit System	C. and R Constr. Co., Rosindale	Sept., 1926	626,550
Illinois		Southern Illinois & Kentucky R.R. Co	W. J. Zitterall Co., Webster City, Ia	Sept., 1926	500,000
Mississippi, Florida and Alabama	143	Muscle Shoals, Birmingham & Pensacola R.R. Co	R. F. Carr, Memphis, Tenn Z. Gardner, McAllister, Okla	Oct., 1926	50,000 70,000
Wasnington	4.3	Bd. Pub. Wks., Skagit River Ry. Extension	Morrison Knudson Co., Boise, Idaho	Oct., 1926	243,448
Mississippi	21	Jackson & Eastern R.R. Co	S. K. Jones Constr. Co., Memphis, Tenn. and others	Oct., 1926	200,000
Illinois	10.5	St. Louis Connecting R.R. Co	Walsh Constr. Co., Davenport, Ia	Oct., 1926	615,000
California	10	San Gabriel Canyon R.R.	Nevada Contg. Co., Fallon, Nev	Oct., 1926	276,425
Ohio	63.23	Chesapeake & Hocking Ry. Co	Fritz-Rumer Cook Co., Columbus, O., and others	Nov., 1926	12,500,000
Ohio and Michigan	21.6	Wabash R.R. Co	Industrial Track Construction Co., St. Louis, Mo	Nov., 1926	1,400,000
Mississippi and Florida	57.5	St. Louis-San Francisco Ry. Co	Ross-Wogan Constr. Co., Kansas City, Mo	Dec., 1926	800,000

Engineering Construction Activity Indicated by Heavy Bond Sales

THE favorable investment market last month brought the state and municipal bond disposals to the highest total recorded since December, 1925. The total awards, according to the *Commercial and Financial Chronicle*, was $169,257,044 as compared to $143,562,277 in December, 1926 and $69,742,193 in January a year ago.

New York City headed the list of largest bond offerings, selling four issues of 4½s aggregating $60,000,000 at 102.6489, a basis of 4.12. Detroit came next with eight issues of 4½s and 4¾s, aggregating $14,505,000. Miami, Chicago and Buffalo follow with issues of $10,345,000, $5,456,000, and $5,260,000 respectively.

The following table compares the emission of long term borrowings in January over a period of eight years.

1927	$169,257,044
1926	69,742,193
1925	135,536,122
1924	99,625,470
1923	96,995,609
1922	108,587,199
1921	87,050,550
1920	83,529,891

What Money Costs for State and Municipal Improvement Purposes As Shown By January Bond Sales

State	Purpose	Amount	Rate Per Cent	Sold For	Basis	Dated	Maturity	Purchased By
North Dakota	School	7,500	5				1946	State of North Dakota
County								
Allen, O.	Bridge	15,500	5	100.62	4.86		1927-35	Provident Savings Bank & Trust Co. of Cincinnati
Beaver, Pa.	Road	500,000	4½	101.51	4.09	Feb. 1	1928-52	W. H. Newbold's Son & Co. of Philadelphia
Broward, Fla.	Highway	400,000	5½	95	5.96	July 1	1935-49	Frank N. Brown of Delroy
Butler, Kans.	Road	80,000	4½	100.11		Jan. 1	1928-37	Branch-Middlekauff Co. of Wichita
Carson, Tex.	Road	300,000	5½	100.27	5.47	Oct. 1	1927-56	Caldwell & Co. of Nashville
Columbiana, O.	Road	35,000	5	102.60	4.45	Jan. 1	1928-37	W. Slayton & Co. of Toledo
Dade, Fla.	Road	500,000	5	95	5.34	Oct. 1	1930-71	Weil-Roth & Irving Co. of Cincinnati and others
Deschutes, Ore.	Road	185,000	5½	100		June 1	1928-34	Northwestern National Bank of Portland
Hamilton, O.	Road impvt.	186,994	4½	100.78	4.34	Dec. 1	1928-35	Herrick Co. of Cincinnati
Hillsborough, Fla.	Highway	610,000	5	100	4.94	Jan. 1	1929-37	Pulleyn & Co. of New York City and others
Jefferson, Ala.	School	600,000	4½	100.18	4.49		1950-55	Marx & Co. of Birmingham and others
Lincoln, Wis.	Bridge	72,000	4½	101.40		Dec. 1		Citizen's National Bank of Merrill
Lucas, O.	Highway impvt.	298,012	5	101.79	4.39	Jan. 25	1929-37	Prudden & Co. of Toledo and others
Madison, Ind.	Bridge	8,000	4½	100			1928-37	Anderson Banking Co. of Anderson
McKenzie, N. D.	Bridge	85,000	5½					Brewer Brown & Co. of Minneapolis and others
Milwaukee, Wis.	Sewerage	1,200,000	4½	103.58	4.18	June 15	1937-46	Harris Trust & Savings Bank of Chicago and others
Montgomery, O.	Bridge	320,000	5			Jan. 1	1928-52	Detroit Trust Co. of Detroit
Osceola, Fla.	Road	1,000,000	6	98.14	6.17	May 1	1936-55	Toledo Brokers
Parke, Ind.	Road	7,700	4½	101.32	4.24	Nov. 29	1928-37	Parke State Bank of Rockville
Stewart, Tenn.	Highway	122,000	5			Nov.	1956	Rogers-Caldwell Co. of New York
Trumbull, O.	Road	24,900	4½	100.53	4.36	Jan. 1	1928-32	Detroit Trust Co. of Detroit
Township								
Haddon, N. J.	Sewer	155,000	5½			July 1	1932-35	M. M. Freeman & Co. of Philadelphia
Hicksville, O.	Road	8,500	5½	103.02	24.85	Jan. 1	1928-36	A. E. Aub & Co. of Cincinnati
Lancaster, Pa.	Road	50,000	4½	100.05	4.49	Jan. 1	1927-47	E. H. Rollins & Sons of Philadelphia
Liberty, O.	Bridge	125,000	5	104.09	4.62	Mar. 1	1927-55	Halleck & Co.
Abilene, Tex.	Water	600,000	5†	100.41				Taylor Ewart & Co. of Chicago and others
	School	200,000						
	Street impvt.	150,000						
	Auditorium	60,000						
	Sewer	50,000						
	Fire station	25,000						
Ashland, Ky.	Water	100,000	4½			Aug. 1	1963-64	James C. Wilson & Co. of Louisville
Bay Village, O.	Street impvt.	616,162	5	100.29	4.92	Dec. 1	1928-32	George W. York & Co. of Cleveland
Bristol, Va.	Street impvt.	255,000	5	100.56		Mar. 1	Serially	Weil-Roth & Irving Co. of Cincinnati
Brooklyn, N. Y.	Road impvt.	42,000	4.325	100.06			1928-41	C. W. Whitis & Co. of New York City
Dearborn, Mich.	Water	270,000	4½	101.95	4.34	Jan. 15	1927-56	Stranahan Harris & Oatis, Inc. of Toledo
East Aurora, N. Y.	Paving	9,500	4½	100.29	4.71	Jan. 1	1928-42	Manufacturers & Traders Trust Co. of Buffalo
Fargo, N. D.	School	25,000	5	100		Nov. 1	1931-35	State of North Dakota
Harnell, N. J.	Street impvt.	37,041	4½	100.129	4.48	Feb. 1	1928-33	Manufacturers & Traders Trust Co. of Buffalo
Indianapolis, Ind.	Bridge	60,000	4½	103.58	4.09	Jan. 1	1929-48	Meyer-Kiser Bank
Jacksonville, Fla.	Street impvt.	300,000	5	102.91	4.30	Sept. 1	1931	Guaranty Co. of New York City
Liberty, N. C.	Water and sewer	40,000	6	100.12	5.99	Jan. 1	1929-59	Magnus & Co. of Cincinnati
Louisville, Ky.	Sewer	1,500,000	4	100.10	3.99	Feb. 1	1965	First National Bank of New York City and others
Minneapolis, Minn.	Street impvt.	1,131,056	4½	100.92	4.11	Feb. 1	1928-47	Eldredge & Co. of New York City and others
Mocksville, N. C.	Water	25,000	5½	102.92	5.51	Jan. 1	1930-61	N. S. Hill Co. of Cincinnati
New York, N. Y.	Rapid transit	$50,000,000	4½	102.6489	4.12	Jan. 6	1967-77	National City Co. of New York and others
	Water supply	5,000,000						
	Dock impvt.	2,500,000						
	Municipal	2,500,000						
	Street impvt.	750,000						
Omaha, Neb.	Sewer	500,000	4¼	100.019	4.20	Feb. 1	1947	United States Trust Co. of Omaha and others
	Park	100,000						

Weekly Construction Market

BUILDING materials, at principal producing and distributing centers throughout the country, occupy a price level about 5 per cent below that of a year ago. Wholesale prices of all commodities are approximately 6 per cent under general levels obtaining at the outset of 1926. Hence it is seen that the movement of prices in this particular group are consistent with the trend in markets for other materials of everyday use.

About the only exceptions offered is in the case of common brick, which stands a trifle under one per cent above the market of a year ago, in the principal cities.

Structural steel shapes and reinforcing bars, f.o.b. Pittsburgh mill, are quoted at a minimum, 10c. per 100 lb. below prices in effect at this time last year. Steel plates sell at $1.80 to $1.90 per 100 lb., Pittsburgh, or the same as of the last week in February, 1926.

Steel sheets, black and galvanized, dropped 15c. per 100 lb. at Pittsburgh mills during the week.

Cement mill shipments are running at a rate higher than at this time last year. Increased output has served to meet this demand and leave, in addition, mill reserves greater than at the outset of 1926. The cement price situation is, therefore, one of continued stability, with no changes of importance recorded since Feb. 1, 1927.

	New York	Atlanta	Dallas	Chicago	Minneapolis	Denver	San Francisco	Seattle	Montreal
Steel Products									
Structural shapes, 100 lb.	$3.34	$3.80	$4.15	$3.10	$3.35	$3.87½	$3.00	$3.15	$3.80
Structural rivets, 100 lb.	4.20	3.80	4.75	3.50	3.75	4.65	5.00	4.00	....
Reinforcing bars, ¾ in. up, 100 lb.	3.24	2.80	2.75	2.30@2.50	2.87½	3.87½	2.95	3.10	3.57
Steel pipe, black, 2½ to 6 in. lap, discount	48%	54%	54%	51%	54.25%	41%	42@53.8%	45%	37.83
Cast-iron pipe, 6 in. and over, ton	47.60	42.75	56.00	45.20	48.50	62.00	47.00	55.00	62.50
Concreting Material									
Cement without bags, bbl.	2.35@2.55	2.25	2.05	2.05	2.22	2.85	2.31	2.65	1.15
Gravel, ¾ in., cu.yd.	1.75	1.90	2.38	1.85	1.65	1.90	1.80	1.25	+1.90
Sand, cu.yd.	1.00	1.60	2.00	1.56	1.25	1.00	1.40	1.25	1.35
Crushed stone, ¾ in., cu.yd.	1.94	2.50	2.83	1.87½	1.75	2.50	1.70	3.00	2.00
Miscellaneous									
Pine, 3x12 to 12x12, 20 ft. and under, M.ft.	61@63	34.00	56.00	40.00	39.25	32.75	27.00	25.00	50.00
Lime, finishing, hydrated, ton	18.20	23.50	19.00	20.00	25.50	24.00	25.50	24.00	21.00
Lime, common, lump, per bbl.	2.10@3.00	1.50	1.82	1.50	1.70	2.70	1.60	2.80	10.00
Common brick, delivered, 1,000	20.40@22.40	10.50	14.10	12.00	13.75	9@10	15.00	15.00	20.25
Hollow building tile, 4x12x12, per block	Not used	.0895	.112	.076	.076	+.085	.....	.09	.10
Hollow partition tile 4x12x12, per block	.1027	.0895	.112	.076	.076	+.085	.108	.09	.08
Linseed oil, raw, 5 bbl. lots, per 7½-lb. gal.	.84	.90¾	1.10	.85	.93¾	1.07	.91	1.12	1.03
Common Labor									
Common labor, union, hour	.90⅜	.30	..	90	.....	.50@.55	.60	.62½	.....
Common labor, non-union, hour	.....	25	30@.50	....	45@.60	.40@.45	.50	.....	.25@.30

Explanation of Prices—Prices are to contractors in carload lots unless other quantities are specified. Increases or decreases from previous quotations are indicated by + or — signs. For steel pipe, the prevailing discount from list price is given; 45-5% means a discount of 45 and 5 per cent. L.c.l. is less than carload lots.

New York quotations delivered, except sand, gravel and crushed stone, alongside dock; common lump lime in 280-lb. bbl. net and hydrated lime, f.o.b. cars; tile "on trucks"; linseed oil and cast-iron pipe f.o.b. Reinforcing bars (billet steel) and shapes delivered to job in less-than-carload lots.

Labor — Cement and concrete laborers' rate, $1.06¾; building laborers, 90⅜c.

Chicago quotes hydrated lime in 50-lb. bags; common lump lime per 180-lb. net. Lumber, sand, gravel and stone f.o.b.; price on fir is quoted instead of pine. Reinforcing bars (billet steel) f.o.b. warehouse in carload lots; shapes, less-than-carload lots.

Minneapolis quotes on fir instead of pine. Brick, sand and hollow tile delivered. Cement on cars. Gravel and crushed stone quoted at pit. Bars (billet steel) at warehouse in carload lots; shapes, less-than-carload lots.

THIS limited price list is published weekly for the purpose of giving current prices on the principal construction materials, and of noting important price changes on the less important materials. Moreover, only the chief cities are quoted.

Valuable suggestions on costs of work can be had by noting actual biddings as reported in our Construction News section.

The first issue of each month carries complete quotations for all construction materials and for the important cities. The last complete list will be found in the issue of Feb. 3, the next on Mar. 3.

Denver quotes on fir instead of pine. Cement "on tracks"; gravel and sand at pit; stone on cars; lime, brick, hollow tile and lumber on job. Tile price is at warehouse. Linseed oil, delivered in wooden bbl. Common lump lime per 180-lb. net. Bars (billet steel) and shapes, l.c.l.

Atlanta quotes sand, stone and gravel per ton instead of cu.yd. Common lump lime per 180-lb. net. Bars (billet steel) f.o.b. in carload lots; shapes, l.c.l.

Dallas quotes lime per 180-lb. bbl. Cement, cast-iron pipe and crushed stone f.o.b. cars, other materials delivered. Bars (billet steel) carlots; shapes, l.c.l.

San Francisco quotes on Heath tile, size 5½ x 8 x 11½. Prices are all f.o.b. warehouses except C.-I. pipe, which is mill price plus freight to railway depot at any terminal. Common lump lime per 180-lb. net. Lumber prices are to dealers in yards at San Francisco, for No. 1 fir, common. Bars (billet steel) f.o.b. in carload lots; shapes, l.c.l.

Seattle quotes on Douglas fir (delivered) instead of pine. Lump finishing lime per 180-lb. net. Brick and hollow building tile delivered. Hydrated lime in paper sacks. Sand and gravel at bunkers. Bars (billet steel) and shapes, less-than-carload lots.

Montreal quotes on fir lumber. Sand, stone, gravel and lump lime per ton. Stone and tile are delivered; sand, gravel, lime and cement on siding; steel and pipe at warehouse. Hollow tile per ft. Cement price is in Canadian funds (the Canadian dollar stands at 99.84). Bag charge is 80c. per bbl. Discount of 10c. per bbl. for payment within 20 days from date of shipment. Steel pipe per 100 ft. net: 2½ in., $37.83. Bars (billet steel) and shapes, in carload lots.

Unit Prices

For actual prices bid on materials in place at various construction jobs throughout the country, see pp. 128-128A of this issue following Construction News.

On Feb. 1, 1927

E. N.-R. Construction Cost Index Number 210.15

E. N.-R. Construction Volume Index Number 187

For Explanation and Details of Indexes Since 1913 See the First Issue of Every Month